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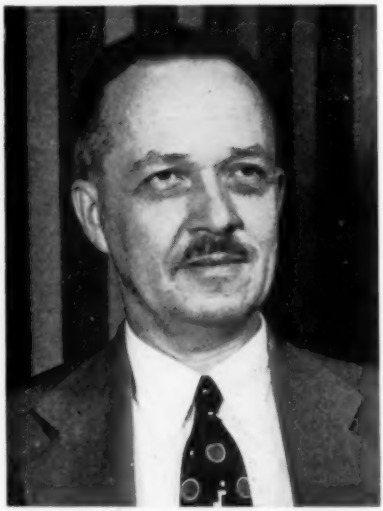
Our New President

George H. Harding, Director of the Mapping and Charting Research Laboratory of Ohio State University Research Foundation, was elected President of the American Congress on Surveying and Mapping for 1952. He was born in Lenox, Ohio, in 1902, and received two degrees in engineering from Ohio State University; B.C.E., 1926, and C.E., 1931. After several years of professional practice in Cincinnati, Ohio, he became a member of the faculty of Speed Scientific School, University of Louisville at Louisville, Ky. Mr. Harding resigned from this position in 1940 to become Assistant Chief, Geodetic Branch, Intelligence Division, Office, Chief of Engineers, War Department, Washington, D. C. His work for the War Department continued throughout World War II and included the following important assignments: Chief, Foreign Map Branch, Intelligence Division, Office, Chief of Engineers, Washington, D. C., 1941–1942; Chief, Survey Liaison Office with G.H.Q. Middle East, Cairo, Egypt, 1942–1944; and Civil Affairs Division, Provost Marshal General's Office, War Department, 1945. He returned to his alma mater, Ohio State University, in 1946 as Research Professor at the Engineering Experiment Station. In addition to his present position as Director of the Mapping and Charting Research Laboratory which he has held since 1947, he is Executive Director of the Institute of Geodesy, Photogrammetry, and Cartography, recently organized at Ohio State University.

Mr. Harding is a charter member of the American Congress on Surveying and Mapping and played a major role in the preliminary meetings and conferences which finally culminated in the establishment of the A.C.S.M. in 1941. He was the first executive secretary of the Congress and held this office until he was called to foreign service in 1942. Since then he has served the society as a member or chairman of many important committees and as a national director and vice president.

Mr. Harding is an active member of the American Society of Photogrammetry, American Geophysical Union, American Society of Civil Engineers, and the American Society for Engineering Education. He was awarded the Order of the British Empire by the British Government for



GEORGE H. HARDING

technical services rendered in the Middle East in 1942–1944. In 1948 he was President, Commission VI, on Education, Bibliography, and History of the Sixth International Congress on Photogrammetry, The Hague, Netherlands. He acted as representative of the National Research Council, American Geophysical Union, and Chairman of the delegation of the Commission on Cartography of the Pan American Institute of Geography and History at the IX International Meeting of the Union of Geodesy and Geophysics held in Brussels, Belgium, in August 1951.

A Policy on Highway Surveys

(Prepared by Control Surveys Division, American Congress on Surveying and Mapping)

In July 1948, a special committee consisting of nine members of the Control Surveys Division, all highway engineers, was appointed to prepare a preliminary text on Highway Survey standards for wide distribution and discussion. This preliminary text and a complete record of the procedures leading to it were published in the July–September and October–December 1949 issues of SURVEYING AND MAPPING.

The preliminary text was referred to the Executive Secretary of the American Association of State Highway Officials and to the U. S. Bureau of Public Roads; the A.A.S.H.O. referred it for consideration to its Operating Committee on Design which comprises a member in each State, D.C., T.H., and P.R., and two members from the U. S. Bureau of Public Roads. Comments on the text were received from 40 members of the committee and all these comments and other suggestions were considered in preparing the revised policy which is published here.

At the Eleventh Annual Meeting at Washington, D. C., June 20, 1951, the following resolution was unanimously adopted by the American Congress on Surveying and Mapping:

"WHEREAS, the value of surveys for highways is dependent upon the accuracy attained through execution in accordance with a recognized standard, and

"WHEREAS, the American Congress on Surveying and Mapping, recognizing the need for a criterion that may be used as a guide in improving and standardizing survey practice, has formulated "A Policy on Highway Surveys" which specifies desirable limits of accuracy for length and angular measurements and determination of elevations in highway surveys, and

"WHEREAS, the adoption and use of these standards will establish procedures resulting in dependable surveys which will serve beyond their initial purpose and become a continually increasing asset in the planning, design, construction, and maintenance of highways, be it therefore

"RESOLVED, that the American Congress on Surveying and Mapping urges the adoption of this "Policy on Highway Surveys" by the American Association of State Highway Officials, and be it further

"RESOLVED, that copies of this resolution be forwarded to the Commissioner of the United State Bureau of Public Roads; to the officers of the American Association of State Highway Officials; and to the Chief Engineer of each Highway Department in the United States, its Territories and Insular Possessions."

—EDITOR

INTRODUCTION

Compliance with reasonable standards of accuracy for measurements made in surveys to establish alignment and grades of highways will develop permanent value for these surveys. Final results will be dependable and the surveys will serve beyond their initial purpose, thus becoming a continually increasing asset.

APPLICABILITY OF STANDARDS

These standards will apply to the measurements of length and angles in the transit traverse for the center line or control base line for the alignment of the highways and to the final adjusted elevations of the bench-mark levels. Achievement of compliance for the basic control or center line surveys will encourage a

correspondingly high precision in all supplemental measurements. Expense of resurveys will be reduced and through the determination of accurate volumes the pay quantities on construction will be correctly indicated.

ACCURACY REQUIREMENTS DEPENDENT ON IMPORTANCE OF HIGHWAY

Maximum accuracy consistent with reasonable economy is desirable for all surveys, but it is recognized that the importance of a highway will have a bearing on the expenditure that may be justified for its survey. Low-type roads of primitive or temporary character do not warrant procedures required for expressways designed to serve a large volume of traffic. Highway systems selected by State Highway Departments are universally accepted as classifications of routes on the basis of their importance. These systems are used as a guide in assigning the order of accuracy for highway surveys, but it is not expected that the designated standards will be rigidly applied. The importance of the highway and value of the property served will be determining influences in the selection of the proper standard of accuracy for the survey.

The order of accuracy as specified for each class of highways is considered to be the minimum requirement. More than usual carefulness must be exercised to insure the desired result.

ORDERS OF ACCURACY

The Approved Specifications for Horizontal and Vertical Control promulgated by the Board of Surveys and Maps of the Federal Government, May 9, 1933, were used as a guide in establishing the orders of accuracy for highway surveys. These specifications apply to surveys for geodetic control to determine the latitude, longitude, and elevations of marked points distributed throughout an area to be mapped. For second- and third-order accuracy these requirements are slightly higher than are economically practicable for highway surveys and to indicate this variation in this standard the prefix "modified" is used.

First-Order Accuracy is required for surveys of major bridges, long tunnels, and all structures of such size and importance as to justify geodetic surveys. The minimum requirements for first-order traverse surveys are that, for length alone, the error in closure shall not exceed 1 part in 25,000 and that the probable error of main scheme angles shall not exceed 1.5 seconds. First-order leveling should be divided into sections not more than a mile in length, each section should be run forward and backward, and the two runnings of a section should differ not more than 0.017 foot $\sqrt{\text{Miles in length of section.}}$ To attain this result the work must be done with a precise prism level and invar-strip rods.

When and wherever practicable survey work requiring first-order accuracy shall be accomplished after consultation, or in cooperation with, the U. S. Coast and Geodetic Survey.

Modified Second-Order Accuracy is required for surveys of highways of sufficient importance to justify expressway, or four or more lanes, as the type of construction. In this class will be included those highways equivalent to the routes on the National System of Interstate Highways through the urban areas of the larger cities. For the transit traverse of the center line, or control base line, the error of closure in position, due to length measurements alone, shall not exceed 0.01 foot multiplied by the number of 100-foot tape lengths, and the error in angular measurements, shall not exceed 20 seconds $\sqrt{\text{Number of angles between tangents of the traverse.}}$ In meeting the accuracy of angle specifications, four or

more repetitions may be required with a 1-minute transit, estimating to the nearest half minute the reading on each vernier.

Leveling for surveys of highways of this class shall be equivalent to second-order leveling as specified by the Board of Surveys and Maps. The work shall be performed with a good engineer's level and target rod, provided the lines are double run, in opposite directions, in sections not longer than 1 mile. If the two runnings of any section fail to agree within 0.035 foot $\sqrt{\text{Length of check section in miles}}$, additional runnings shall be made until two of them are in agreement with this tolerance.[1]

Modified Third-Order Accuracy is required for surveys of highways of sufficient importance to justify the construction of two or more lanes to serve traffic. In this class will be included highways on the National System of Interstate Highways outside of the urban areas of the larger cities, or their equivalent. Some sections of this class may be of sufficient importance as to require modified second-order accuracy. In this class will also be included highways on the Federal-Aid System and important highways on the State Highway Systems as well as highways of similar importance on other systems. For survey of highways in this class the error in closure of position on the transit-traverse of the center line, or control base line, due to length measurements alone, shall not exceed 0.02 foot multiplied by the number of 100-foot tape lengths, and the error in angle measurements shall not exceed 40 seconds $\sqrt{\text{Number of angles between tangents}}$ of the traverse. In meeting the accuracy requirement for angles it will be necessary to measure each angle at least twice with a 1-minute transit, estimating to the nearest half minute the reading on each vernier.

Leveling for surveys of highways of this class shall be equivalent to third-order leveling as specified by the Board of Surveys and Maps. It should not be extended more than 30 miles from lines of first or second order. Lines should always be loops or circuits closed on lines of equal or higher order. Lines having closing checks failing to agree within 0.05 foot $\sqrt{\text{Length of check section in miles}}$ shall be re-run until two runnings agree, with this tolerance.

Surveys for highways of less importance than those listed in the foregoing classifications should be executed with the highest degree of accuracy consistent with administrative economy. Many sections of highways on State systems of principal secondary or feeder roads, county highways, and others are of sufficient importance to be classified for surveys of third order or higher.

It is emphasized again that these are minimum requirements and that more than usual carefulness must be exercised to insure the desired results.

Tests of Accuracy.—The best test for compliance with these standards is a check of length and azimuth between two or more points on the geodetic network of the Coast and Geodetic Survey or other points whose positions have been established, adjusted, and for which State standard plane coordinates are available. Where available within reasonable economic range, points with known ad-

[1] Some members believe that the last two sentences of this paragraph would be more surely understood if worded thus: The work shall be performed with a good engineer's level and target rod, and the lines double run in opposite directions. Bench marks shall not be spaced farther apart than 1 mile. If two runnings of any line or section between bench marks fail to agree within 0.035 foot $\sqrt{\text{Length of line or checked section (in miles)}}$, additional runnings shall be made until two of them are in agreement with this tolerance.

justed positions should be tied in to the highway survey and used to check its accuracy. State standard plane coordinates shall be used to establish the location of points on the highway survey, whenever possible. Good loop closures are generally indicative of good work, but it must be remembered that if a loop is run entirely with a single tape, the closure of that loop will not reveal any defect in the length of the tape. Inaccurate tape length will be revealed, however, in the closure of a nearly straight route between two triangulation stations on the geodetic network. It is very important to have the tape standardized, so that the results of the survey will be expressed in correct units of length. If the survey is at high altitude, there is an appreciable difference between measured distances and the sea level distances used in geodetic control surveys; this should be taken into account in determining the error of closure.

Loop closures may be made when two or more lines are run for a survey, such as on a preliminary line and on a location line, or where the highway survey crosses another survey of known adjusted accuracy.

Leveling on highway surveys should be checked for accuracy by comparison of elevations with those of the first- and second-order lines of levels run by the U. S. Coast and Geodetic Survey and by the U. S. Geological Survey if these are within reasonable range.

GENERAL CONSIDERATIONS

In the development of a highway project from reconnaissance through construction there are many opportunities to check and recheck measurements. Careful adjustment of measurements and faithful recording of final results will increase the value of the survey. Planning of survey operations, reasonable attention to field practice, and preservation of records are essential to attainment of the accuracy of these standards.

Survey monuments and bench marks must be constructed so as to be permanent in character, and shall be located where they will be most useful during the construction period and for reference in planning future surveys in the area served by the highway. Points selected as permanent markers shall be perpetuated by firmly setting a non-corrodible metal plug in bedrock, a large boulder, concrete post, or a permanent structure. Traverse monuments preferably shall be located as intervisible pairs, where they can be occupied by a transit, in order that they may define azimuth as well as position. Selected right-of-way markers, specially constructed to insure permanence, make good monuments. For accurate fixing of a center line tangent, a survey monument may be set at the intersection of the projected tangent with the right-of-way line. At all survey monuments, one or more reference points should be established where they will not be disturbed.

Maximum care, consistent with reasonable cost, must be employed in all survey operations. All transits, levels, and other instruments must be maintained in precise adjustment and all tapes, rods, thermometers, plumb levels, etc., must be kept in good serviceable condition. Suitable entries shall be made in the field notes to indicate that the instruments and tools are in condition to provide accurate results. A complete, concise record shall be kept of all survey procedures and other circumstances which may have weight in judging the accuracy of the survey.

With all corrected notes recorded for each survey, including the circumstances prevailing at the time each measurement is made, such as weather con-

ditions, pull on the tape, etc., the degree of accuracy may be increased by mathematical correlation and adjustment of the complete survey record. The final accuracy attained should then be defined in accordance with these standards; the angles and distances recorded on the as-constructed plans for future use.

The results of the traverse and leveling must be listed in form for limited distribution, so that the data will be available for future surveys.

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New National Geographic Map of the United States

A NEW 10-color map of the United States based on the 1950 census has recently been issued by the National Geographic Society. The map is 41 by 26½ inches in size and is on the scale of 78.91 miles to the inch.

The map bears 11,025 place names—over 2,000 more than appeared on the 1940 National Geographic map of the country. Most of these are located in the Western States, the region of greatest percentage growth during the past decade.

Red lines bearing highway numbers show the main roads in the United States and neighboring areas of Canada and Mexico. Cities having airports with regularly scheduled commercial service are starred in red.

Inset in the lower right-hand corner are the Canadian Maritime Provinces of Nova Scotia, New Brunswick, and Prince Edward Island, plus the Gaspé Peninsula. A larger-scale inset, at 16 miles to the inch, shows the New York area.

Residents of the United States and its possessions may obtain copies from the National Geographic Society, Washington 6, D. C., at $0.50 per copy on paper and $1.00 on linen. An index to the map costs $0.25. In foreign areas $0.25 should be added to these prices.—Condensed from *The National Geographic Magazine,* June 1951.

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ICAO Aeronautical Chart Catalogue

THE International Civil Aviation Organization at Montreal recently issued the *ICAO Aeronautical Chart Catalogue,* containing indexes and lists of internationally available aeronautical charts produced by the contracting states of ICAO. Each index or list of charts briefly describes the chart series portrayed and gives the necessary purchase data and an indication of the extent to which a series conforms to the standard specifications contained in Annex 4 to the Convention on International Civil Aviation-Aeronautical Charts. The catalogue is published trilingually (in English, French, and Spanish) in loose-leaf form to facilitate amendments.

Copies may be obtained at a price of $4 (Canadian), which includes a 21-ring binder and amendment service for 1 year. The amendment service thereafter will be 50 cents (Canadian) per annum.—*International Hydrographic Bulletin,* April 1951.

Survey and Describe Your Land

By WM. C. WATTLES
LICENSED LAND SURVEYOR AND REGISTERED CIVIL ENGINEER

IN THIS AGE, the manifold activities of industry demand specialization which, with its concomitants, accuracy and efficiency, provides a satisfactory solution to the problems of business life. This holds true in land survey and title insurance practice.

The transfer and encumbrancing of real property, the insurance of title, the making of ground surveys, and the preparation of record descriptions demand particular care in all their phases in order to escape the many pitfalls which give rise to misunderstandings, arguments, lawsuits, and financial loss.

Of all the items entering into a project involving real property, probably the least considered are the survey and description, although they are of utmost importance. The survey is the physical and the description is the written record of the position or location of the parcel of land dealt with in the transaction. No accurate information may be had nor specific knowledge obtained in land holdings and transfers without an accurate survey and its associated description. A true title description may not be written without the anchor of fixed position.

One does not take a watch to a blacksmith for repair; neither should one attempt a survey or description of property unless qualified by training and experience. Title companies, by their very nature as investigators and insurers of titles, are especially fitted, with their legal departments and engineering staffs, to prepare and interpret descriptions and to give accurate advice and to check on the location methods of surveyors. They are also familiar with the variety of needs of the parties to a transaction and can determine the manner of procedure required for final and satisfactory location of boundary lines.

Also very necessary, especially in localities not served by title companies, are the services of competent and qualified land surveyors who are experienced and familiar with the intricacies and vagaries of surveys, descriptions, and titles.

The great variety of dimensions, designations, and relationships of boundaries creates a corresponding variety in the type and form of description that will define correctly such boundaries. The description must also conform with title, and provide sufficient data or references for a correct location survey. The scope of this paper will not permit an investigation of the full technic of property surveying or description writing, but a few broad applications may be stated. The conclusions presented are based on legal and surveying principles.

From the standpoint of the land owner, the location survey is probably more important than the title description, but the title man subordinates the survey to the description. The record title is evidenced by a permanent document usually recorded, which in itself does not change, and may be used at any time for comparison or check with any other related instruments. The surveyed location is not necessarily permanent, being subject to change from natural causes, destruction of monuments, changes in the locations of structures, differences in

Mr. Wattles is chairman of the Technical Division on Property Surveys of the American Congress on Surveying and Mapping.

measurements made by different surveyors, and other matters which do not find their way into the records. Therefore, in spite of the usual legal preference and decision as to the superiority of physical monuments over the record data relating to the same, it seems more logical that the fixation and continuity of titles should be obtained by the analysis and maintenance of the records, related and adjusted to the physical evidence.

In general, a description should be as short and simple as possible, consistent with the information to be given; complete and specific as to the locations of the boundaries, whether designated by dimensions or by recitals and ties to adjoining lines and monuments of record; readily interpretable using the ordinary methods of mathematics and the principles of law and surveying; devoid of uncertainties and ambiguities; clear as to intent; and free from excess language that adds nothing to the meaning or construction.

The difficulties resulting from prevalent unfamiliarity with the preparation and interpretation of description, or the making and checking of any required surveys, are best remedied by placing the work of analysis and adjustment in the hands of title engineering experts.

Since the description is the written evidence of record, it follows that it should conform with ground conditions precedent thereto, and discrepancies should be corrected by proper amendment of the record, revising the description to fit the ground. However, as is frequently the case, when property lines are determined and descriptions prepared from a theoretical lay-out, or a compiled map of adjacent lands, the surveyor must establish the lines on the ground in agreement therewith. Failure to do so will tend to invalidate the monuments set to mark such lines as being representative evidence of the described land, and subsequent use of such monuments will cause conflicts in title, with all the associated aggravations.

A parcel of land which has been passed from owner to owner during a long period of time by re-use of the original description, maintains its boundary form of record; but occupation, faulty description or location of adjoining lands, or subdivisional changes may require a modernization of description for accurary and ready understanding, and is usually advisable. Such modernization, properly devised and executed with adequate references to the old record, will require no agreement deeds for adjustment and the revised description can be used safely in future instruments. When ownership of property changes, boundaries are altered, or new physical appearances are created, an adequate survey and map should be made, monuments should be verified or reset, the old description should be checked (a new description prepared if necessary), making necessary changes and new title insurance obtained. The added expense will be more than justified by security of ownership provided.

A description based on a mathematical foundation and a series of fixed bearings and distances from a beginning point or line common to a similar description of adjoining property, may not require additional calls or ties for title safety. However, the great majority of descriptions are made safer by reciting calls and ties to monuments of record. This prevents overlapping or gapping of adjoining properties, and shares the burden of boundary identification with the adjoining descriptions already of record. This matter of including ties to monuments of record is a source of much argument between surveyors and title men, the surveyors claiming that it increases the difficulty and cost of

the survey, while the title men contend that the extra effort is justified by safeguarding the title and permitting a more flexible adjustment of questionable lines. The justification in the argument that a description is safer and more certain where a maximum of ties and a minimum of dimensions are involved is two-fold; it is claimed, first, that there is less danger of conflict in titles, and second, that there is a greater demand on the surveyor to make proper investigation and not take the easy way out by using dimensions of doubtful reliability.

Survey errors or mistaken ideas as to boundary line dimensions or directions are responsible for many description difficulties, especially in those instances where supposedly adjoining properties are described independently, each being tied to a different corner of a larger parcel, but with no ties from one to the other. The sum of several tract boundary lengths along a line may equal an original record call, but a resurvey may show a definite shortage or surplus. Since the dimensions given in the deeds are fixed, a disagreement arises along the intended common boundary of the parcels. To prevent such conflicts, descriptions for parcel division should include ties from a common corner.

The ideal lay-out for conveyance of land is the recorded subdivision plat, particularly in the form developed in California. Most of the information required for the definition of boundaries is shown on the record map, together with much additional data, and parcel delineation is more discernible than the visualization of a metes-and-bounds description. The description of a lot on a map is simplicity itself, merely requiring a statement of the lot number, the City, County, State and the book and page of the record of the map. Even the division of the original lots into two or more parcels is easier, for ties and distances are readily referenced to the lot boundaries of the map. An additional advantage is that proper reference to the map in a document incorporates in the document all the information on the map which may be pertinent to the location of the property, thus eliminating a long and complicated recital of ties, calls, and dimensions in the description.

Metes-and-bounds descriptions, especially if they define very irregular parcels, are difficult to handle both in making surveys and in title work. Unless carefully prepared to ensure mathematical accuracy and proper boundary references, they are dangerous, subject to misinterpretation and clerical error. Also, the surveying and legal construction or interpretation of ground conditions may differ and descriptions in conveyances or other documents should be closely checked, both by title and ground survey, to eliminate any discrepancies.

The use of coordinate values for points and corners in a description introduces a new type of control for physical positioning, making possible the accurate relocation of missing or destroyed corners. But, it must be noted that such relocation is not effective as against other methods, unless the point in question has been assigned coordinate values in some prior description of records; otherwise the coordinate values indicate only the locations of positions determined by the surveyor who computed them from his field data. A description of a definitely fixed boundary, such as an original free survey or a compromise agreement line, in which the coordinates of points are given with proper recitals of base, ties, and other identifying information, provides a very satisfactory record and the maintenance of monument positions by coordinate references is assured. Although recognizing the use of the coordinate system and

permitting its use in descriptions, some states require the subordination of coordinate calls to record calls. It seems, at the present time, advisable to consider recital of coordinates as supplementary and confirmatory to the record call and as a surveyor's tool for ground position rather than a legal monument in description.

Many people dealing in real property divide parcels on the basis of fractional parts of the street frontage, but describe them on the basis of area, such as "west ½" or "east ⅓" of the lot. This is a definite error, since fractions of a lot, unqualified, deal with the area, not dimensions. If a division of the frontage is intended, the description should contain wording similar to the following: ". . . west ½, measured along the south line thereof, of lot . . . ."

The "east half" of a lot, in area, will not represent or include exactly the east half of the frontage, except under special circumstances. There is no technical conflict between the "east" and "west" halves of a lot. There is no fixed rule for determining the dividing line between halves, and any line, straight, bent, or curved, which divides the whole area into equal "east" and "west" parts will be consistent with the description of "half," unqualified. Known intent, possession, and common practice may identify the particular location in any case. The proper form of description is one reciting the position or direction of the dividing line as a supplement to the "half."

Another common practice which results in indefiniteness, is the use of such an expression as "the north 50 feet of lot —." For example: assume a 100-foot frontage lot, facing east, with the side lines extending westerly at an angle from the front line materially different from 90 degrees; the owner claims 50 feet frontage but describes his parcel as "the north 50 feet of lot —." This description cannot give a 50-foot frontage unless the lot is a rectangle. The interpretation of "north 50 feet of lot," is that portion of lot adjoining the north line of the lot and bounded southerly by a line parallel with and 50 feet southerly measured at right angles from the northerly line. Computation in the example here will give more than 50 feet frontage (50 secant of skew angle). The proper wording to use, if 50 feet frontage is desired, is "the north 50 feet, measured along the east line thereof, of lot —," qualifying the location or direction of the dimension.

The assumption that a lot line extends to or is the center line of an abutting street, based on a map notation that the distances or areas are computed to street centers, is considered untenable as a general proposition. Although the title of the half width of the street area adjoining the lot normally carries with and follows the lot, the street area itself, is not a part of the lot. Unless a description contains particular language indicating intent to accept the center of the street as the lot line for the purpose of the instrument, the interpretation of such an assumption is doubtful.

Descriptions taken from tax bills or other assessment documents, whether metes and bounds or parcel form, should never be used in conveyance without rigid examination. The usual practice followed in drafting these descriptions is devised for tax purposes, and has practically none of the elements of safety or accuracy demanded in title work. Although based on records, the ties, dimensions, and directions of traverse are determined for convenience of description rather than conformity with the deed; off-record or quasi record dimensions

frequently are not considered, thereby producing conflicts requiring subsequent adjustments.

An escrow or proceeding in probate involving real property should qualify any descriptions presented thereto until such time as there is submitted a final and accurate draft, carefully checked as to sufficiency, accuracy, and title status.

Any question arising through discrepancy between physical position and paper or record location necessitates, as a preliminary to adjustment, an accurate ground occupational survey and a map showing all data from the survey compiled with affecting record information. An adjustment can then be made by an exchange of deeds which will either coordinate the record with the possession, or provide a shift in occupation to fit the record.

Errors in surveys or descriptions of adjoining parcels of land often create or destroy areas between such parcels, of unknown or indeterminate dimensions. The problem of fixing a common boundary becomes one involving survey and conveyance. The survey must indicate the position and ties from the agreed line to some undisputed line of the larger involved area, or other acceptable associated lines. The conveyance must contain a description of the agreed line, properly tied to determinable monuments, as shown by the survey, and contain proper words of agreement and grant to establish title to each side of the compromise line. The document, of course, should be recorded. Precise description of the controversial area is usually neither possible nor advisable, but the dividing line must be specifically located and described.

Many who write descriptions, through eagerness to prevent misunderstanding or desire to maintain an ultraconservative legal phraseology, or hampered by inability to make complete use of the technical meaning of words, fill those descriptions with much superfluous or duplicate phrasing and reiteration. In many instances no harm is done, the only effect being a tedious, redundant, and word-burdened instrument. However, such excess wording, especially if it forms the substance of double calls in dimension or multiple ties, not only increases the difficulty of analysis, but may endanger the clarity and precision of the description. For example, nothing is gained in meaning or accuracy by stating "A lot, piece or parcel of land lying in and being a portion of that certain land known as Tract Q, and being more particularly bounded and described as follows to wit," instead of "That portion of Tract Q, described as follows." There is a mere matter of 31 words as against 8 to express the same idea. Likewise there is no particular value in the use of "to a point" at the end of every dimensional phrase, unless the point has a peculiar designation or tie which distinguishes it. Mathematically, every described portion of a line terminates in a point and no uncertainty is involved in the omission of the phrase. In the event it is desirable or necessary to give more than one tie or designation to a point, line, or monument, care must be taken to indicate clearly which is the major or governing tie. This may be done by priority of call and by the use of qualifying words, such as "also," "being," and "more or less."

On the other hand, descriptions may fail through excessive brevity, with fatal omissions which prevent accurate interpretation. To cite an example, a description reading "Lot 8, being a parcel 50 by 100 feet on B Street," is inadequate in view of the knowledge that the size of Lot 8 is actually greater than stated and the location is not defined. In another case, "one acre in the S.E. quarter of Section 15," is invalid for lack of certainty.

Descriptions containing inaccurate statements, or references to features not mentioned in the record, such as impermanent physical objects, are at least dangerous if not actually insufficient, if the location of the property depends on such items. The information may be sufficient in defining the intent and understanding of the parties to the transaction, and as between them establish a valid transfer, but as a matter of record for future operation, it is untenable.

A description of a line or area should be so clear and definite or, in the case of adjustment of error, so inclusive, that a surveyor may use it with certainty in fixing a precise and definite ground location. He may have to run out adjoining boundaries from other deeds to ascertain his position, and may be required to interpret items of variance between deed descriptions and ground monuments, but with a good description of the particular land in question, the problem is easier and the chances of error less.

Any survey of land, whether an original separation of a parcel from a larger area, or relocation of the boundary of an existent parcel, should be sufficiently complete and accurate to provide the data required to prepare a map showing all the information necessary for description of the desired portion, including required ties.

The information on the map should be such that a title check against the record will indicate all agreements or disagreements so that the record description can be made to conform to the ground location, and both support the title.

The land owner depends on the title company and the land surveyor to protect his interest.

The title man and company maintain the integrity of the owner's property as of record and insure his rights against loss.

The land surveyor acts as an expert fact finder and analyst, lending valuable support and accurate technical aid in correlating possession with description, and furnishing the owner and title company with the necessary data for complete and satisfactory title to the property.

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Government Issues Book on Scientific Research

SCIENTIFIC RESEARCH in engineering schools of the country and the part these schools are playing in training scientific manpower are the subjects of a new book entitled "Review of Current Research."

Published by the Engineering College Research Council of the American Society for Engineering Education, the review outlines policies and activities of engineering research in the 91 colleges and universities holding membership in E.C.R.C. The volume also shows for each school the names of responsible research administrative officers, the number of personnel engaged in research activities, the annual expenditures, and special conferences and short courses of interest to research workers.

In all, more than 5,200 engineering research projects, representing annual expenditures of over $50,000,000, are now under way in the engineering schools of American colleges and universities; the research projects listed represent the work of more than 11,500 faculty members, graduate students, and research engineers. Listings of projects and personnel are complete as of March 1, 1951.

The book may be obtained from the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C., for $2.25, payable to the Treasurer of the United States.—*Engineering News-Record,* June 21, 1951.

The Mapping Program of Cincinnati and Hamilton County

By H. H. KRANZ
CITY ENGINEER, CINCINNATI, OHIO

THE CITY OF CINCINNATI, in conjunction with Hamilton County, has embarked on a comprehensive mapping program designed to cover the entire city-county area of 414 square miles on 610 map sheets at a cost, including reproduction and control, of $1,120,000. In this project, Cincinnati is following a precedent established in 1912 when a topographic map, on 48 sheets to a scale of 1 inch = 400 feet and with a contour interval of 5 feet, was made as part of a complete underground sewerage investigation of the city. This 1912 map is extremely accurate and useful and is referred to constantly by our division and others. However, the elements of growth in population, expansion in area, and many new internal developments have rendered many sections of the 1912 map obsolete.

Cincinnati is continually faced with problems arising outside its corporate limits which require joint action with either the county or abutting municipalities. When, therefore, the director of the Coast and Geodetic Survey offered to participate in the establishment of a first-order network, a mapping project was set up for the entire city-county area. Assurance was obtained from Hamilton County that it would participate financially. The city and county agreed to share equally in the cost of mapping the 3-mile band of county area contiguous to the city's corporate line; cost of mapping the balance of the county would be paid entirely by the county and the balance of city area by the city. All of the work would be administered by the city.

AERIAL PHOTOGRAPHY AND PHOTOGRAMMETRY

The decision to delineate the maps by photogrammetry had been made rather early in the project following an analysis of the comparable costs of ground methods. After investigation of the recognized leaders in the field of photogrammetry, Fairchild Aerial Surveys, Inc. of Los Angeles was selected as consultant to develop the maps from air photographs. By arrangement with Fairchild, separate agreements are to be signed for various areas as budgetary allotments are made available, each area containing a specified number of map sheets. Under these agreements, Fairchild will supply the following:

1. One set of 737 negatives and two sets of contact prints of photography to a scale of 1 inch = 1,000 feet, to be used for stereo-compilation.
2. One set of 1,682 negatives and two sets of contact prints of photography to a scale of 1 inch = 600 feet, to be used for photo-atlas sheets.
3. Color separation drawings of the agreed number of map sheets to a scale of 1 inch = 200 feet and with a contour interval of 5 feet, for the following colors:
   (*a*) Black—street lines, houses, boundaries, etc.

Presented at the Annual Meeting of the American Society of Civil Engineers, joint session of Surveying and Mapping Division and City Planning Division, New York, N. Y., January 1950.

Mr. Kranz died June 10, 1950.

(*b*) Blue—streams, lakes, rivers, etc.
(*c*) Brown—contours at intervals of 5 feet.
(*d*) Green—wooded areas larger than 1 acre.

4. Photo-atlas sheets of the agreed number of map sheets to a scale of 1 inch = 200 feet. Each photo-atlas sheet to have grid lines and geographic tick marks and to be identical in corners and area to the corresponding map sheet.

5. A film composite positive of the color-separation drawings, in register.

The aerial photography was accomplished by the use of two planes: a Fairchild 71 and a Waco. A K-17 camera with a 6-inch lens was used for making the photography at the scale of 1 inch = 1,000 feet required for the topography. A special camera with a 24-inch lens was used for the mosaics or photo maps. The actual photography was accomplished in 16 days, although flying extended over a period of 2 months. Delay was caused by a combination of early spring, with premature budding of foliage, and serious flood conditions.

Compilation of stero-manuscripts for topography is done by Fairchild on the Zeiss stereoplanigraph. The basic plans for the black-line separations showing street and public boundary lines are being penciled by the City Engineering Division because of the accessibility of property records. The balance of the processing—the platting of buildings—is then completed by Fairchild.

TRIANGULATION

The procedure used on the first-order control network for the Cincinnati project is outlined in the manuals published by the Coast and Geodetic Survey.

Under an arrangement with this agency, the city paid the per diem costs of Federal personnel, supplied a field engineer and engineer aids, miscellaneous supplies, transportation costs, and the maintenance of Federal vehicles. The Coast and Geodetic Survey provided the loan of all precision instruments, two panel trucks, 14 Bilby steel towers, miscellaneous precision equipment, and the salaries of Federal personnel. The arrangement was so satisfactory to the city that I would recommend its adoption by others contemplating a similar mapping program.

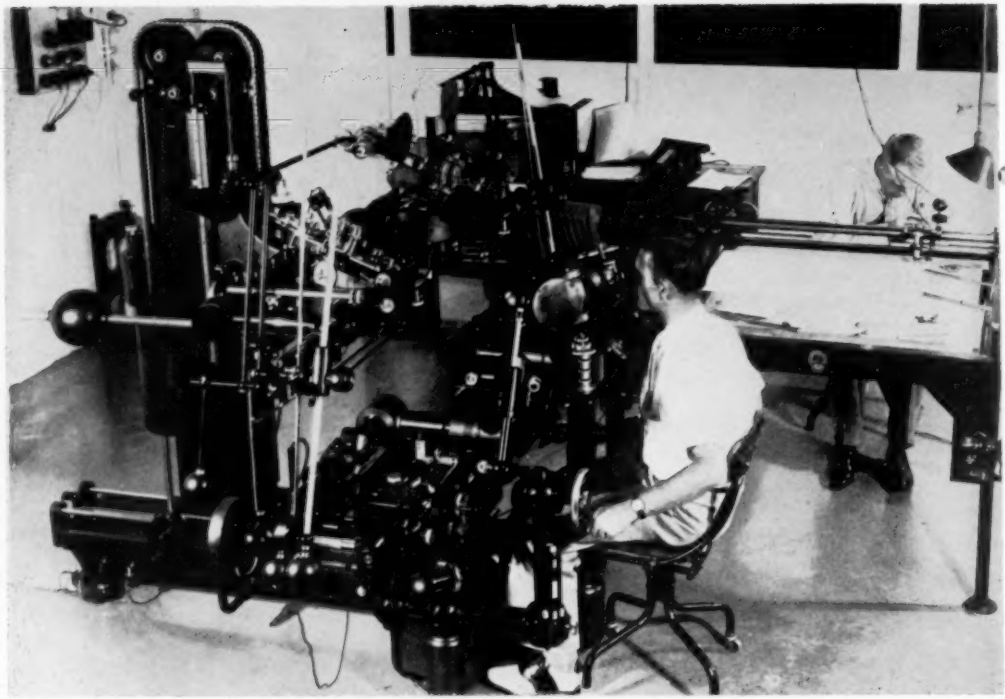
First-order control cost was $32,091—an average of $412 per station. In the Cincinnati project 42 main, 36 supplemental, and 74 intersection stations were established covering an area of 880 square miles and with a total length of 91 miles as measured along the axis of arc. Four base lines, 14.07 miles in length, were measured with an average accuracy of 1:4,925,000. The average length check to base lines was 1:153,000 and the average position closure to existing triangulation 1:325,000.

LEVELING

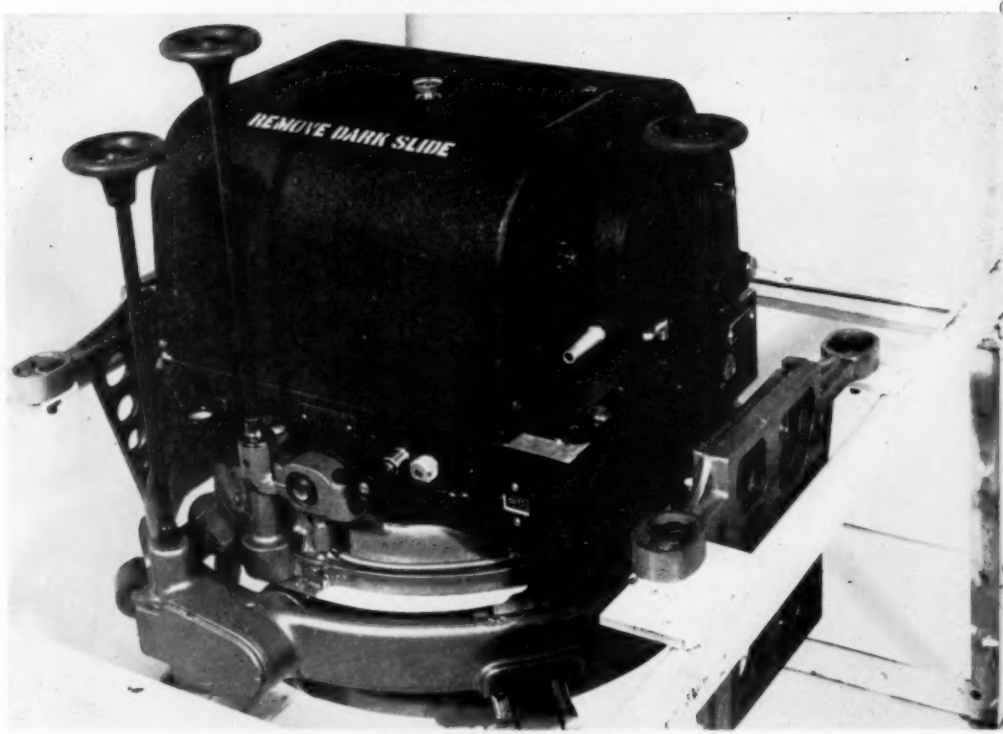
During the initial phases of the triangulation, the city realized that a recheck of its basic datum and bench marks would be a desirable safeguard before proceeding with the detailed topography. The Coast and Geodetic Survey, therefore, at the city's request, participated in establishing 10 complete closed level loops plus additional spur lines totaling 80.6 miles. With this precise level net as the basis, secondary circuits have been planned, to dovetail with the traverse and picture-point control and establish elevations of new monuments as well as elevations of photo-control points.

MAP CONTROL—SECONDARY TRAVERSE

It was with some apprehension that the City Engineering Division assumed the responsibility for the horizontal and vertical traverse network necessary to



ZEISS STEREOPLANIGRAPH IN OPERATION

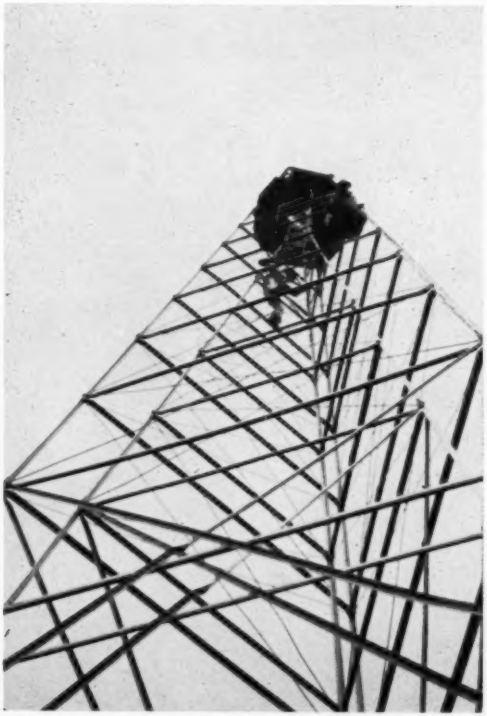


FAIRCHILD K–17 CAMERA

WILD TRAVERSING TARGET

PRECISE TAPING

TRAVERSE MONUMENTS



BILBY TOWER CONSTRUCTION

control the mapping, primarily because it was believed that adequate personnel to handle this phase of the work could not be obtained. However, with the assistance of manuals published by the American Society of Civil Engineers entitled *Horizontal Control Surveys to Supplement the Fundamental Net* and *Technical Procedure for City Surveys,* and manuals available from the Coast and Geodetic Survey, specifications were developed that enabled one field supervisor to plan work on a production-line basis so that the responsibility of the several crew chiefs is not great and the work is routine.

The field organization consists of one base-line crew and one angle crew, and one utility crew which alternates from check profiling of finished topographic sheets to referencing supplementary photo control points and semi-precise leveling while office computations are coordinated by an assistant engineer and several engineering aids.

The primary reason for retaining the traverse operation in the City Engineering Division was to develop a high concentration of permanent monuments of fixed vertical and horizontal position, for the use of the city and county in controlling new subdivisions and future developments and for the convenience of engineers, surveyors, and all agencies dealing with land measurement. In the process of establishing this network, therefore, the referencing of secondary points for map control was readily absorbed.

The monuments are being spaced to give a concentration of approximately two or more pairs to the square mile, and so placed that one monument of each pair is intervisible with the other. This permits a quick check of each monument, and gives the user not only a starting azimuth but a check as to elevation.

Angle Measurements

The specifications for accuracy adopted for control of the traverse follow generally those used in standard practice. All traverses are to be first order with an average position closure of 1 : 30,000, and a maximum position closure of 1 : 20,000 after distribution of azimuth closures. Traverse lines are to be considered of first adjustment if they originate and terminate upon triangulation stations and of second adjustment if they fall outside this category.

The adopted criterion of average angular closure between adopted azimuths is given by the equation $E = 4\sqrt{N_t}$, where N_t is the number of instrument stations on the line, and E is the error in seconds. The results obtained from 125 miles of traverse, including 640 angle stations, indicate that these specifications can be met quite readily without the use of highly specialized personnel. In general, the measurements taken during 1 year of operation have averaged 0.52″ for angular error with an average position closure of 1 : 39,000.

Upon the advice of the Coast and Geodetic Survey, we obtained a Wild Universal T2 Theodolite and have since obtained two Wild traversing targets. Both the theodolite and targets have optical centering, internal illumination, and interchangeable tripods. The use of these instruments alone has simplified the taking of angular measurements to such an extent that the angle crews are often waiting for the taping crew to catch up.

Taping

Taping is being done by use of K & E Lovar tapes, 100 feet in length, standardized by the National Bureau of Standards for two supports. Temperatures are read from thermometers fastened directly to the tape, and a uniform

tension of 20 pounds is maintained by means of a tension handle at the forward end. After experimenting with several types of taping bucks we have standardized on two types—the plumbing buck and the line buck. The line buck is made of steel tubing and is used for intermediate support between angle points; the plumbing buck is rather heavy and is used only over an angle point or fixed monument where it is necessary to plumb. Elevations are run over the tops of all bucks and the measurements from these elevations are reduced to horizontal.

The taping crew consists of six men assigned to the following duties: front tape contact and recorder (chief of party), front tension, rear tension, rear contact, level, and level rod. Each traversing operation begins with a preliminary reconnaissance by the crew chief and field supervisor followed by rough taping to determine the positions of the taping bucks. Precise measurements are then taken over the predetermined 100-foot spacing of the taping bucks by means of markings made on renewable copper strips by the forward contact man using a scratch awl. In most instances precise taping measurements can be made as fast as a man can walk.

REPRODUCTION AND FINISHED MAPS

The city has contracted for one thousand reproductions of each of 25 map sheets, 16 of which have already been printed.

The finished maps are in four colors and conform with the Army Map Service ink color guide. The topographic maps are prepared at a scale of 1 inch = 200 feet; contours are indicated at 5-foot intervals. State coordinate grid lines are shown and geographic coordinates indicated by tick marks. The maps have an over-all size of 24 by 35 inches with an inside printed area of 20 by 27½ inches. East and west margins will be 3¾ inches each, the north margin (top) 1½ inches, and the south margin (bottom), 2½ inches. It is anticipated that those map sheets and photo-atlas sheets which must be used for reference will be bound face to face in books of about 20, so that both photograph and map will be readily available for all purposes.

For field use, the composite film positive to be furnished by Fairchild will be used to produce prints by standard reproduction processes.

PROJECT COST AND FINANCING

An itemized cost, per map sheet, is given below. It has been included with some hesitancy, and is recited solely to benefit engineers of other cities who may be budgeting for mapping programs, and who can profitably use the experiences of Cincinnati. The costs have been developed after 1 year of operation, utilizing a field section of 18 men, an office section of 3 men, and a basis of production of 80 map sheets per year.

Operation	*Cost*
Triangulation and first-order levels (city cost only)	$ 53.00
Traverse	425.00
Levels—second order	92.00
Photo control and check profiling	91.00
Aerial photography	12.00
Stereo-compilation of color separation drawings	600.00
Photo-atlas sheets	60.00
Lithographing and binding (1,000 copies)	400.00
Total unit cost per map sheet	$1,733.00

The project is being financed by yearly allotments made available by the Council of the City of Cincinnati and the Commissioners of Hamilton County. These allotments are determined on the basis of a year's production, so that any funds which might be needed for other purposes are not unnecessarily restricted. The work is being carried out under the general direction of the city engineer and has been specifically assigned to B. H. Kock, senior engineer, for detailed supervision. The field work is in charge of L. F. Ferguson, assistant engineer, and all office work, including computations and drafting, is supervised by C. F. Pugh, assistant engineer. All construction work required, and manufacturing and setting of monuments and position marks, is carried out by the Highway Maintenance Division of the city under the direction of C. E. Brokaw, superintendent. Coordination of the phases of mapping involving Hamilton County is under the direction of George M. Lemmel, county engineer. The city is particularly indebted to Rear Admiral L. O. Colbert, former Director of the Coast and Geodetic Survey and members of his staff, notably Rear Admiral J. H. Hawley, former Assistant Director; Capt. H. W. Hemple, Chief, Division of Geodesy; L. G. Simmons, Principal Geodetic Engineer; and C. T. Husemeyer, Chief of the First Order Control Party. The city has also been assisted on many occasions by the helpful suggestions of Leon T. Eliel, vice president, Fairchild Aerial Surveys, Inc., and C. B. Foster, photogrammetric engineer assigned to the Cincinnati project by Fairchild, who have greatly simplified the technical problems arising from the development of maps by the photogrammetric process.

Discussion

By FORD BARTLETT

ASSOCIATED WITH LOCKWOOD, KESSLER AND BARTLETT, INC., BROOKLYN, N. Y.

MR. KRANZ has clearly presented how the city of Cincinnati has solved its mapping problem economically. The cooperation of the Coast and Geodetic Survey, Fairchild Aerial Surveys, Inc., and the City Engineering Division, all under the general direction of the City Engineer, has proved to be a very satisfactory arrangement. Each contributing organization is performing that part of the work in which it is expert.

Cincinnati is one of a number of cities that has recently demonstrated that it is possible to provide an up-to-date topographic map in a reasonably short time by using aerial photogrammetric methods. I understand from Mr. Kranz's discussion that they expect to produce 80 map sheets a year; a total of 610 map sheets are required for the 414 square miles. This would indicate that the project will be completed in 7 to 8 years. This length of time has probably been determined by budget limitations as well as availability of personnel. This period seems long when compared with the 16 days required to accomplish all photography. Actually, it is very short when compared with the time required to produce these same maps by ground methods. The estimated cost of $1,120,000, or about $2,700 per square mile, is probably less than 50 percent of that which would have been spent if ground methods only were used.

Those concerned with city planning, traffic studies, transportation, property location, public works, location of utilities, and tax assessments are only a few of those who will appreciate the value of the city map. The cost of the project should be returned to the city and county many times as the maps are put to use.

On a recent occasion we had prepared maps for a comparatively small community. The City Engineer informed me that as a result of the use of these maps, he had been able to make extensive modifications in the design of a storm-water sewer system and in so doing had been able to save the taxpayers of the community a sum four times the cost of the maps.

Sometimes, however, the results of mapping programs are rather embarrassing. A client who owned a large tract of land within the limits of the city of New York engaged us to prepare a topographic map of his holdings. The map was duly completed and, at his request, filed with the municipal authorities. To his embarrassment, but to the delight of the city fathers, it was found that he had 300 acres of property in excess of the area delineated on the assessment maps. The assessment was on an acreage basis and needless to say the city jumped at the opportunity to increase its take in taxes.

Undoubtedly, many city planners have been confronted with problems similar to those in our fair city of New York, where generations ago rectangular street patterns were laid down and became the official city map. Thousands of these so-called paper streets were never actually developed. As a result, when one asks for a copy of the official city map of an area, he is apt to get a beautifully drafted sheet showing 80-foot avenues, 60-foot streets, and 200- by 700-foot blocks, as well as official grades. These grades may consist of the proposed elevations at the four street corners and were devised to provide a drainage pattern. It is quite possible that no topography had ever been taken of the area and there may be no relationship of these grades to the actual ground elevations. Obviously, the whole map contributes little of value from the standpoint of intelligent planning. The usefulness of this type of map is small when compared with a modern topographical map, which, in addition to showing all cultural features, makes clear all man-made improvements, such as traveled roads, buildings, and pole lines. The need for these accurate maps is definitely established. Maps are not spectacular or dramatic, and it is hard to imagine a ceremony with local dignitaries gathered around to cut the ribbon on the first set of prints.

Mr. Krantz presented effectively the need for up-to-date maps to the city and county officials. I would be happy to learn how this was accomplished and how the funds were appropriated.

Another question I would like to ask regarding this mapping project, which is pertinent to the photogrammetric mapping of any city with tall buildings, is how was the problem of plotting contours in the streets adjacent to tall buildings overcome? By that I mean one contact print of a stereo-pair may show the street clearly from building line to building line. The following or overlapping print will possibly be at such an angle that the roadway will be obstructed by the buildings. This would make it impossible for the operators to obtain a stereoscopic image.

CATALOGS ON AERIAL SURVEYS

Two new catalogs describing various aspects of aerial surveying have recently been published by Lockwood, Kessler and Bartlett, Inc., of Great Neck, N. Y. One contains information on how to obtain a resources inventory in under-developed areas. The other tells how to obtain fast, economical ground profiles by radar.—*Engineering News-Record*, May 31, 1951.

New Concepts Needed for Topographic Mapping

By JAMES A. PATTERSON
PENNSYLVANIA DEPARTMENT OF COMMERCE STATE PLANNING BOARD

MAP USERS throughout the nation continue to be disappointed in the progress of topographic mapping. Despite constant demands for accelerating the programs, mapping needs continue to grow faster than mapping accomplishments.

Attention was focused on the lack of adequate maps back in 1934. At that time it was estimated by the U. S. Geological Survey that 47 percent of the United States had been topographically mapped, but that less than half of the mapping met the needs of the day. Considering the many uses made of topographic maps and the number of years that we have had an organized mapping program, it seemed unbelievable at that time that such a condition could exist.

The year 1934 marked the beginning of a new trend in government operations —an era of state and national planning. Each state became interested intensely in the way its land was being used, in its soils, in its minerals, in its waters, in its forests, and in all its natural resources. Inventories of all these resources and their uses were needed. Topographic maps furnished an ideal base upon which to assemble and study these varied data, but adequate maps were available for only a small part of the nation. Each state also became aware of numerous unwise uses of land, water, and other resources, and became interested in correcting these conditions. Again, topographic maps were the ideal base upon which to chart conservation plans, but they were not available. Pressure was exerted to improve conditions; recommendations were presented, mapping needs were published widely, but the expected results were not forthcoming. Thus, much of the money expended for state planning studies was unfruitful and the waste of natural resources continued unabated.

Meanwhile the Federal Government, through the National Resources Board and later through the National Resources Committee, was busily campaigning for conservation movements. Drainage basins became their fundamental unit for planning. TVA was established to demonstrate the advantage of unified planning. Billions of dollars worth of projects were listed in preliminary studies, but basic topographic maps were not available for determining the feasibility of the preliminary studies or the drafting of detailed plans. TVA then evolved its own mapping program, contracting with the U. S. Geological Survey for most of the work. Mapping crews and facilities were withdrawn from other parts of the country in order that the maps could be prepared for TVA on schedule. Throughout the nation flood control, irrigation, and navigation studies were initiated in various places. In some instances schedules were rearranged in order that the necessary maps would be available. In other cases they just weren't drawn, despite the need for them and the pressure brought upon the mapping agencies to furnish them.

Presented at Eleventh Annual Meeting, American Congress on Surveying and Mapping, Washington, D. C., June 18–20, 1951.

Periods of defense preparation and actual warfare followed in quick succession; great emphasis was placed upon mapping, especially in the coastal belts; agencies which normally did not prepare topographic maps were pressed into service, as well as commercial mapping agencies. After the war ended, mapping activities in the United States remained near the wartime peak and new techniques and improved methods were integrated firmly in all mapping agencies.

During this period dating from 1934, industries, public utilities, and state and Federal agencies all joined together in their efforts towards accelerating the mapping of our nation. In 1950 the U. S. Geological Survey estimated that topographic maps were available for nearly 50 percent of the United States but that only one-half of these were adequate for modern needs. Sixteen years of concerted pressure and frenzied mapping activity had resulted in boosting the total coverage from 47 to 50 percent, with half the maps being classified as inadequate.

At present, approximately 2,000 quadrangles are being mapped, the majority of them being 7½-minute ones; about 500 are completed each year. At this accelerated rate of progress it will be 50 years before we have adequate topographic maps of the nation, based upon present-day standards. And it is only natural to expect that present-day standards will not be high enough to meet the needs 50 years hence.

When we examine the reports of the topographic mapping agencies, it becomes apparent that more than one-third of all the topographic mapping activity lies within the Missouri River Basin, in which lives approximately one-twentieth of our population. The need for obtaining topographic maps of this basin prior to the detailed planning and construction of the gigantic water projects scheduled by the Federal Government is recognized. Engineers and map users all hope that these basic maps will be available in time to prevent the staggering waste which would result if construction should precede mapping. But there is also a widespread belief that the mapping of this area is being accomplished at a great cost to other areas that need adequate maps to meet the problems of their people. For example, in the Delaware River Basin, which contains parts of New York, New Jersey, Delaware, and Pennsylvania, there is almost no topographic mapping activity. This, despite the fact that the Delaware River is of vital importance to a vast industrial area, including not only the five million people living within the basin but also ten million others in the New York City area who are becoming increasingly dependent on this river as a source of public water supply, and to the nation, which depends on the industries of this area for many of its military materials. While it is true that topographic maps are available for most of the Delaware River Basin, many of them are obsolete and of little value for planning. In many other areas, mapping activity apparently is being retarded while the Missouri River Basin project is being expedited.

In other areas, such as California, Oregon, and Washington, the Government has scheduled major projects. Topographic mapping in these areas is being pushed. Large areas of Connecticut and Kentucky are being favored because of cooperative mapping agreements with those states. Mapping projects of a cooperative nature and projects in which Federal agencies have an interest are given special consideration. These special projects now utilize more than half of our topographic mapping facilities.

Priorities and schedules for mapping are determined largely from requests

originating in the various Federal agencies and requests from states for mapping on a cooperative basis. Although other requests from the states and individuals are given consideration, they seldom gain positions of high priority. A quadrangle which is given a second priority rating may remain in that category for many years and cannot advance until it gains special consideration by being included in a cooperative program or is urgently needed by one or more Federal agencies.

In Pennsylvania, as in many states, the majority of the government agencies look with favor upon cooperative mapping. However, in most states that have cooperative programs with the Federal Government, the state's share is appropriated for the purpose of providing a base for geologic mapping. While geologic mapping is of great importance, especially in a state like Pennsylvania, there are dozens of other important uses being made of topographic maps. Those other uses in their aggregate involve many more persons and are of a greater dollar value than the geologic mapping uses. For every geologist, there are a hundred map-using engineers and technicians. For every hundred dollars worth of mineral deposits discovered each year by the geologists, there are thousands of dollars spent for transportation facilities, water supplies, sewage treatment works, public utility lines, industrial plants, and conservation measures under the direction of engineers and technicians.

The U. S. Geological Survey is fulfilling in a magnificent manner its allotted task of providing base maps for geologic mapping and for projects of Federal agencies. The Army Map Service has expanded its facilities tremendously and has furnished the great quantities of maps needed for military operations. The Coast and Geodetic Survey has provided the basic control networks and has assisted in the development of instruments and techniques. But somewhere along the line the needs of the engineer, the planner, the technician, and a host of other map users have been sidetracked. Apparently no mapping agency has ever been definitely assigned the responsibility of providing topographic maps for this group.

The number of topographic maps sold is not a true index of our needs. Their use is restricted by poor distribution methods. In Pennsylvania it is possible to obtain topographic maps in only 17 towns, and very often the person selling these maps knows little about them. Of course, they can always be obtained from the issuing agency, but if people had to write to Washington for a pair of glasses or a hammer there would be few of these commodities sold. As can be expected, there are few topographic maps sold. If a person could go to the post office, a store, or an office in any village and purchase a topographic map of the surrounding land and order maps for any area of our country, the sale of these maps would soar.

There has never been any serious attempt to teach people about the surface of our earth, which is the source of their food, clothing, minerals, fuels, and all other forms of wealth. As our soils become thin and gullied by erosion, our forests consumed, our mineral deposits depleted, and our streams choked with silt, it becomes increasingly important that we pay attention to our earth. Each year, as more and more of our resources are wasted, we become more and more dependent on other nations for raw materials. Our people must be made to realize the importance of the thin layer of soil comprising nature's laboratory, in which physical, chemical, and biological processes simultaneously and con-

tinuously take place. They must comprehend the forces which tend to disturb the fine balance between all these processes, and learn how to keep them balanced so as to conserve our land.

Government agencies have recognized this need for conservation. They have trained thousands of technicians to demonstrate conservation practices, and plans are being made to expand these practices tremendously. The basic trend that is being established for these programs provides for conservation measures through government technicians on every acre of our land. Admittedly, the cost will be great—probably greater than we can bear during this period of mounting burdens.

Government technicians are not the only persons concerned with land. Every American has a great interest not only in protecting America but in protecting every acre of America. These people are intelligent, inquisitive, capable of grasping fundamentals quickly, and willing and able to carry out plans for their welfare and betterment. They do not need an army of government technicians to practice conservation on their land; they would rather do things for themselves. But they do need guidance and understanding. They need to understand the language of maps so that they may know how the land which they use fits into the larger pattern. Only then may they be taught the principles of conservation and be able to guide the forces of nature and of mankind towards the protection of our natural resources.

These are the people who should use topographic maps and the maps should be designed for their use. The maps should also be designed for use with aerial photographs. Every square mile of a map should contain a number of definite landmarks which can be located on the ground and upon the photographs without great difficulty. Where a power line is shown, the location of the towers or supporting poles should be indicated. Where the aerial of a television or radio broadcasting station appears on a map, the effective elevation of the aerial should be shown. The extent and type of data shown for farmland should be uniform; the extent of data shown for urban areas should also be uniform, but not necessarily the same as that for farmland. Where 10-foot contours are of importance they should be mapped; where 50-foot contours are sufficient it is a waste of time and effort to show 10- or 20-foot contours. Hachures and shadings should be used where they add to the readability of a map, though not necessarily throughout the entire map. Every effort should be made to make the maps more readable and to eliminate or change any symbols that may be misleading.

One of the biggest tasks that faces us is to educate the youth in our schools and in the armed forces, as well as adults, to understand topographic maps. Obviously, many years would be required to train qualified instructors for this purpose by ordinary methods; but by utilizing plastic models, film strips, motion pictures, and displays, a coordinated training program can be evolved which will accomplish this. With properly designed aids, it should be possible to give the average person or class a workable understanding in the use of topographic maps in less than 10 hours of instruction. Every person in our nation should receive this instruction.

This is an opportune time to activate such a program. Our armed services have a definite need for mapping instruction in order that our forces may take advantage of all natural features for defensive and offensive measures. Our civilian defense agencies have a definite need for this program; for as long as

atomic bombs exist, our people must be able to appraise the surrounding land forms and select the best places of shelter in case of attack. Our people in their daily lives need this knowledge so that they may map out a program for becoming masters of the land and change the pattern of governmental domination which is being charted for them.

We need a topographic mapping program that will meet the needs of the nation and its people; we need maps that are designed for use by the average person; and we need an educational program to train people to understand maps. The American Congress on Surveying and Mapping is the only organization in a position to organize and direct a militant campaign to insure the adoption of a satisfactory program.

Discussion

By ROBERT H. LYDDAN

U. S. GEOLOGICAL SURVEY

EDITOR'S NOTE.—At the conclusion of Mr. Patterson's paper, R. H. Lyddan spoke from the floor, complimenting Mr. Patterson on the basic theme of his paper but proposing to comment on several of the details. Inasmuch as the chairman had already indicated that the program was behind schedule, and that time for comments was quite limited, Mr. Lyddan suggested that he submit his comments in writing for publication as a supplement to Mr. Patterson's paper. The chairman accepted that suggestion, and the following comments were received from Mr. Lyddan.

MR. PATTERSON is to be congratulated for having so clearly outlined the need for a mapping program of such extent and vigor that the job of getting this country adequately mapped may be completed in a reasonable period—something considerably shorter than the 40 to 50 years that will be required at the present rate. However, I wish to take issue with some of the things said by Mr. Patterson, although I want to point out first that my comments are not intended to detract from the main theme of his paper, which I endorse completely.

In regard to the mapping in the Missouri River Basin, it is true that about one-fourth of the U. S. Geological Survey's mapping program during the last 3 or 4 years has been within the Missouri River Basin. However, that mapping is financed with funds especially appropriated to the Bureau of Reclamation for an integrated Missouri Basin development program. The money thus made available is in addition to the money normally appropriated for mapping, so it is not correct to think that by expediting the mapping in the Missouri Basin, the mapping in other parts of the country is correspondingly retarded.

Mr. Patterson states that the Geological Survey mapping program is primarily designed to accommodate the map needs of Federal agencies and those states which cooperate financially; that most of the state cooperative programs are tied in with geologic programs while other more important map users are neglected; and that no mapping agency has been assigned the responsibility of providing maps for that very important group of map users, the engineers and planners.

The Geological Survey now has 27 cooperative programs; in 11 of these, state geologists are the cooperating agents but in the other 16, state engineers, highway departments, or state development departments are the cooperating agents. On a dollar basis about 20 percent of the cooperative work directly involves state geologists while 80 percent involves the others named above. The two largest cooperative programs are with the State Engineer in California and the Agricultural and Industrial Development Board in Kentucky.

It is true that in selecting areas for noncooperative mapping, the Geological Survey tries to accommodate the needs of the Federal agencies which use maps; however, we have no intention of neglecting state or local requirements. We need only to be made aware of such requirements so that they can be considered along with others in the scheduling of new work.

In Pennsylvania, a very comprehensive study of map needs from the State's viewpoint was made by the State Planning Board in 1945. We have used that report, along with the requests for mapping in Pennsylvania as submitted by Federal agencies, in determining areas where the combined need for mapping seems to be greatest. We are now mapping 16 quadrangles in the Pittsburgh area and 7 quadrangles in the Philadelphia area. Mapping in those two areas was started largely because the concentration on map needs, as determined by the State Planning Board, was shown to be greater in those two areas than anywhere else in the State.

It is true that the Geological Survey has largely reoriented its mapping program in the light of defense requirements that are now upon us. When the present emergency has passed, however, we will again be able to give attention to the over-all map requirements—both civil and military.

As to whether there is an agency directly concerned with the map needs of the engineering groups, the request for funds that the Geological Survey presents to Congress each year has, for a long time, been justified on the grounds of a general-purpose mapping program designed to accommodate all map requirements that can be met with quadrangle-type maps. The fault has not been due to the absence of a Federal agency concerned with the engineering map user, but rather with the rate of progress, which has been so slow that it appeared to the engineer that no one was interested in his map needs. That fact is recognized in House Document No. 706 in which it is not recommended that any new Federal agency be established, but that the mapping of the country be expedited and brought to completion in a reasonable time.

These comments do not detract from the validity of Mr. Patterson's basic theme that the map needs of the engineer and engineering planners are tremendous, and that the present mapping program does not provide this group with the maps they need. The job to be done, therefore, and one to which Mr. Patterson and other map users might give some thought, is the job of informing state and national leaders as to what the nature and extent of these map needs are.

* * *

Automatic Plotting

A NEW TELEPLOTTER registers 40 points per minute, thereby saving time in the manual plotting of thousands of points. It operates from digital data furnished in the form of IBM cards, introduced by means of a keyboard. The Teleplotter uses digital electric counters and a photoelectric "reading head," which counts the lines and spaces on the graph paper in each of two perpendicular directions.

This photoelectric scanning of the graph paper is direction sensitive and makes the accuracy of the plotting independent of paper stretch, precision of ruling on the paper, size of the chart, and similar variables. Either linear or logarithmic paper can be employed. There is a choice of five scale factors on each axis, and five different symbols are available so that five curves may be plotted on the same piece of paper. The maximum plotting area is 26 by 55 inches, and the plotting accuracy is plus or minus one-quarter of a grid space.—*Aero Digest,* July 1951.

Map Reproduction in Arctic Areas

(Release from the Engineer Research and Development Laboratories, Fort Belvoir, Va.)

MAP REPRODUCTION by the lithographic process in Arctic areas presents some major problems, the foremost of which is maintaining the necessary range of temperature and humidity within which operations must be carried on. In fact, no matter where reproduction equipment is set up, if the working temperature is allowed to drop below + 50° F., the reaction of the chemicals slows up, the equipment becomes too cold to operate, and the efficiency of the operators is greatly lessened. If the temperature drops much lower, photographic and lithographic reproduction become practically impossible.

Reproduction trains required for the production of military maps in the field are composed of a number of individual vans, each housing equipment required for one or more of the component steps of the lithographic process (i.e.

Exterior view of a standard Corps of Engineers map-reproduction van.

camera section, plate processing, map layout, etc.). To assure maximum efficiency and quality it was necessary to develop a satisfactory means of maintaining constant temperature and humidity control under a wide range of conditions within each van. The Engineer Research and Development Laboratories at Fort Belvoir, Va., concluded that, of the various oil furnaces and electric and gasoline heaters tested for the purpose, the gasoline burning heater would most nearly fill military requirements for map reproduction vans.

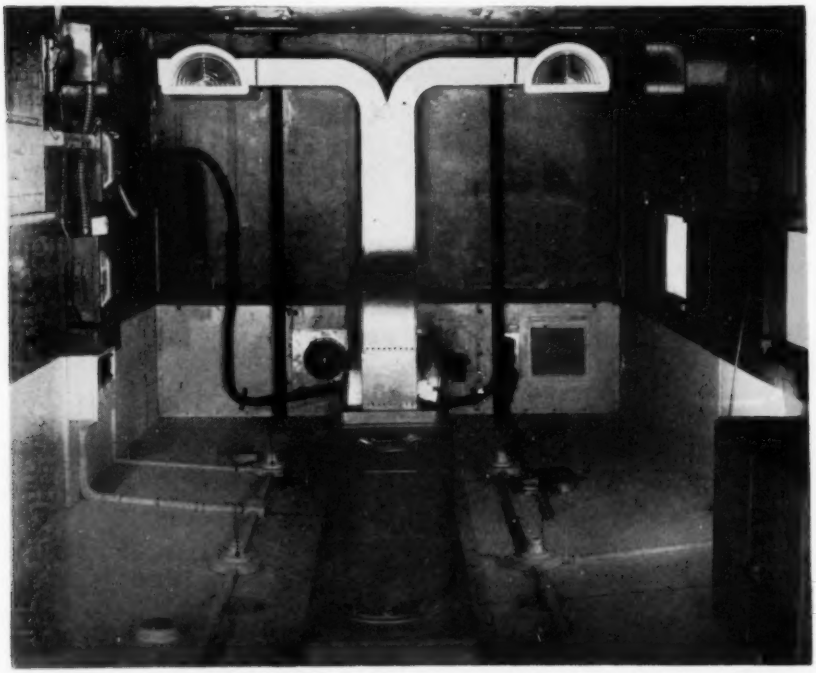
In June 1947, the Laboratories contracted with the Anemostat Corporation of America to test and modify commercially available heaters to satisfy the specialized requirements of Corps of Engineers mapping units. After extensive

testing and consultation, project engineers from both groups decided on a complete heating, cooling, and ventilating system which will uniformly heat standard map reproduction van-type bodies mounted on a standard military truck chassis in sub-Arctic temperatures.

The major components of the heating and air cooling systems are mounted over the cab in an aluminum shell constructed over welded steel structural supports, and the ventilating system is located within the van.

The main component in the heating system is an S-200 Series Janitrol gasoline-burning aircraft heater. It burns general-purpose gasoline which is supplied from the truck gasoline tank and piped to the heater through either of two separate fuel systems. Operation can be switched from one fuel system to the other from within the van and, through proper use of the manually operated shut-off valves, either of the complete systems can be removed for repair while the unit is operating on the other.

The combustion chamber is so arranged that a spinning action is imparted to the flame. The spinning air intermixes with the atomized fuel at the point of ignition and produces a stable, whirling flame which sustains combustion under the most adverse conditions because it is whirled around itself many times. Thus, ignition is continuous and the combustion process "self-piloting." The combustion chamber and heat transfer section are of sufficient capacity to



Interior view of van, showing the split heating diffusion system utilizing air diffusers for side-aisle passages. Ducts and diffusers in the ceiling circulate cool air.

provide a maximum of 200,000 B.t.u. per hour output, depending upon the fuel and combustion air rate. However, the requirements for military mapping are only 50 percent of the maximum output, or 100,000 B.t.u. per hour. Use of the oversized combustion chamber is expected to increase its life span and will also guarantee increased capacity if needed.

At temperatures down to −70° F., the heater can be started and operated with 110-volt a.c. power and will heat the van interior to +65° F. within 1 hour from the initial cold start, using 100 percent ambient fresh air. Recirculated air or a mixture of fresh and recirculated air can also be used. In addition, 24-volt batteries can be utilized as the power source.

Safety was one of the major considerations in the design of this heating system. Since the heater draws its fuel from the truck gas tank, the danger of fire caused by filling conventional heaters while in operation is eliminated. In addition, the combustion chamber is equipped with a safety drain which prevents the accumulation of unburned gas. A drainage line extends from the heater down to the chassis of the truck, where it discharges its contents onto the ground. Thus the danger of carbon monoxide being introduced from the heat exchange chamber or from the exhaust of the heater into the van body has been minimized. As an additional safety factor, the heater is capable of unattended operation through the use of thermostatic controls.

All of the air cooling components except the control box containing the compressor motor starter are also encased within the same housing as the heater. The control box is mounted within the van body. The same axial flow blower with its ½ hp., 24-volt, d.c. motor which is used in the heating cycle is also employed to supply air for the cooling cycle. With an output 70 percent greater than the air conditioning units currently issued, this device maintains temperatures within the maximum limit for efficient operation of motorized map-reproduction equipment. Diffusion of cool or hot air is accomplished by a system of air ducts and diffusers mounted on the ceiling and along the lower front panel of the van. The system can be regulated to provide the mixture and circulation of air desired and provides a uniform heating of the van interior from the floor to ceiling with no stratification or layering. The air-cooling system, like the heating system, is thermostatically controlled.

The entire unit was subjected to temperatures of −40° F. at Fort Churchill, Canada; of −65° F. in the Cold Test Chamber at Eglin Field, Fla.; and of −70° F. in the Cold Test Chamber at Fort Belvoir, Va. Under all of these extreme climatic conditions the unit continued to operate efficiently.

The use of this heating system is but one example of a continuing program being conducted at the Engineer Research and Development Laboratories to provide maximum efficiency in the operation of topographic equipment under the extremes of temperature and climate encountered by our military forces anywhere in the world.

* * *

A summer project at the Library of Congress, carried out in cooperation with several universities and learned societies, resulted in processing approximately 100,000 maps formerly held in dead storage. The Map Division of the Library now has a collection of more than 2,000,000 maps, 17,000 atlases, and several hundred globes.—*The Professional Geographer,* September 1951.

Development of British Surveying Instruments

By D. R. STANLEY

DIRECTOR, HILGER AND WATTS, LTD., LONDON, ENGLAND

EDITOR'S NOTE.—The following papers, by D. R. Stanley, A. M. Caesar, and Carl W. Keuffel, were presented by the Surveying Instruments Division at the plenary session of the Congress presided over by L. C. Higbee, chairman of the Division.

BRITISH instrument-making has a long history. The needs of sailors and navigators led to great development in astronomy and navigation by the heavenly bodies, which in turn stimulated the development of instruments such as the sextant and the theodolite.

In this development Ramsden is an outstanding landmark. In 1777 he constructed the dividing engine, which, although hand-operated, was better than anything previously made. The first accurate sextants were made with this machine, and later in 1792 the circles for the large theodolite used in the principal triangulation of Great Britain. These instruments were read by three micrometer microscopes to 1 second of arc, an accuracy previously unobtainable.

In 1826 William Simms invented the self-acting mechanism that made the dividing engine automatic, and in this tradition Mr. George Watts, the son of the founder of the firm of E. R. Watts, set about making the first Watts dividing engine in 1904. I ask to be forgiven for mentioning this in detail, but it is typical of the care and skill upon which the modern British instrument industry is built. Imagine yourself faced with a revolving table 4 feet in diameter with silver bands set into the face near the circumference and with the edge turned perfectly smooth and true. With great care and concentration one silver band was divided up into 4,320 spaces, representing 5 minutes each. These were calibrated and transferred to a more accurate row of graduations. This process was repeated more than a dozen times, until from quite empirical beginnings a row of 5-minute graduations, accurate to less than 1 second, was obtained. From these graduations it was a relatively simple matter, though very laborious, to cut around the edge of the table two rows of teeth of 10-minute and 5-minute spacing respectively. This tremendous effort undoubtedly laid the foundations for the subsequent growth of the firm.

The firm of E. R. Watts might also be quoted as an example of commercial enterprise. Although comparatively small in those days, they set up in 1907 service departments and retail establishments in three principal cities of Canada.

Surveying instruments of those days were relatively large and clumsy, but there was continual progress by the English manufacturers to improve their designs.

The firm of Zeiss in the early 1920's brought out its revolutionary optical theodolite, and this achieved such remarkably accurate results in an instrument of comparatively small size, that it was not long before British manufacturers turned their attention to the possibilities of glass circles and optical methods of reading. Great credit is due to the firm of Cooke, Troughton and Simms, who brought out in 1926 their famous Tavistock theodolite, which gave optically

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meaned readings to 1 second in an entirely new manner, avoiding the use of the Zeiss patents.

About the same time, Watts acquired a license from Zeiss to use their system and brought out their Monocular Micrometer Theodolite.

By the outbreak of the World War II additional models were on the market: Cooke, Troughton and Simms with a Geodetic Tavistock and two smaller models, one optical scale and the other optical micrometer reading, and Watts with their Microptic theodolite reading to $\frac{1}{10}$ minute.

The war effort stopped further progress, but it is probably correct to say that the most noteworthy feature of postwar development has been the introduction of the new Watts Microptic range, which sets a new standard in compactness of design, and the introduction of pleasing curves instead of the sharp corners so frequently associated with the older instrument-design. Time does not permit a full description of this newly designed range, but I might draw attention to the circle reading system of the 1-second reading Microptic theodolite. This has an entirely new method of graduation and meaning of opposite readings, different from both the Zeiss and the Tavistock methods. The circle carries a composite graduation which, in effect, is three separate scales. The outer is a row of 10-minute graduations figured at every degree, and this appears in the field of view of the reading microscope with a fixed fiducial line, enabling an approximate reading to be taken or a setting made. The next row is of 20-minute spacing and appears in a smaller aperture, only wide enough for two divisions at the most. The third row is also of 20-minute spacing and consists of pairs of lines about 1 minute apart. The image of this row from the other side of the circle is projected on to the 20-minute lines appearing in the small aperture. The optical micrometer is in this part of the system, so that it is only the image of the double lines which appears to move. In practice the 20-minute lines are elongations of alternate 10-minute graduations, and the double line is produced by ruling a second short line alongside the extension. Certain advantages are claimed for this method of reading, notably the increased precision obtained from a "balanced" setting, i.e. setting one line between two. The light gap of this setting is, of course, invariable and unaffected by any circle eccentricity.

Much intensive research has been undertaken, as a result of which the new instrument designs are based on the extensive use of aluminum alloys, hardened parallel steel axes, and glass scales.

Another development which has taken place and which is still in progress is the change in manufacturing method. Rising labour costs have forced the British manufacturers to adopt techniques more like those with which the American manufacturer is familiar. Pressure die-castings, stampings, and interchangeability of parts all have their influence on design and standardization of product. Much work has been done on photographic reproduction of circles, and this method is largely used, though Watts have also done a great deal of development in dividing engine design, and improved models are continually being put into service.

With regard to future trends, there is no doubt that the adoption of modern production methods will continue to affect the appearance of instruments and lead to greater standardization, and it might be claimed that a greater emphasis is being placed on appearance by British manufacturers.

One difference between British and continental European manufacturers is the preference of the British for packing the theodolite horizontally instead of

vertically. The vertical method is attractive in its simplicity, but experience has shown that the risks of transport are no less than they were, and that a theodolite needs to be supported in a comfortable manner, and as far as possible to be relieved from the strains and stresses caused by heavy jolts in transport. The metal box with fitted desiccator takes care of the filming problem.

With regard to new instruments in the future, the design effort since the war has been great, but further instruments are now on the drawing board, and it is hoped that the results will be shown at future meetings of the Congress.

Continental European Surveying and Mapping Equipment

By A. M. CAESAR

PRESIDENT, HENRY WILD SURVEYING INSTRUMENTS SUPPLY COMPANY OF AMERICA, INC.

THE ALLOTTED TIME permits only a brief summary of the history of the development of modern geodetic surveying instruments in Europe since the invention of the modern theodolite.

The year 1910 marks a turning point in the development of geodetic instruments, for prior to 1910 all leveling instruments were open levels. The level tubes were graduated and the bubble was centered in a position symmetrical to the graduation lines. The telescopes were relatively long and lacked luminosity. The reticles were made mostly from spider webs and they were focused by means of an eyepiece drawtube, in many cases not sealed against dust and often constructed without threads or rack-and-pinion movement. The drawtube moved the objective and the reticle along the optical axis of the telescope, towards or away from the object. The eyepieces did not have a diopter scale. The axis systems were "adjustable" by means of a number of screws and the bearings of the trunnion axis were, in most cases, bare and unprotected. The circles were either plated or made of silver and they, too, were exposed both to the weather and to direct damage. The tangent screws were not protected from dust and humidity, and the so-called central clamps were only used here and there.

Theodolites usually had two reading devices on the horizontal circle and, in most cases, on the vertical circle; they were almost always verniers. Reading microscopes with drawtube and rack-and-pinion focusing were used only on special triangulation theodolites.

The transits that were manufactured after the year 1900 occasionally had scale or vernier microscopes (for instance, Fennel). All instruments were heavy, and to be transported they usually had to be taken apart. Naturally, whenever they were put together again, they had to be readjusted with great loss of time. For example, Dr. Wild states that, when working for the Swiss Topographic Survey in 1902, he had to "adjust" his theodolite about 3 hours when on a mountain peak, and when finished with the adjustments, clouds had come up and he was forced to leave again. The instrument was so heavy that it was stored away on the mountain peak under rocks. Afterwards a snowstorm covered the peak and the instrument, and the survey was postponed.

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These cumbersome procedures prompted Dr. Wild to investigate means of improving surveying instruments. In 1908 Dr. Wild joined the Zeiss Optical Company in Germany, for an opportunity to develop his ideas. Zeiss, up to that time, had not made any geodetic instruments, but had a great deal of experience and high reputation in the manufacture of precise optical and mechanical parts and the ability to mount them with great stability. Their microscope department made very precise and fine screws, guides, and toothed gears.

In the rangefinder department, a great number of optical and mechanical parts had to be, and were, mounted precisely and safely for rough use. The designers were good, but they did not know about geodetic instruments. Dr. Wild, from his experience, only knew the difficulties in using surveying instruments in the field. Therefore, the chief designer of astronomic instruments was assigned to him as a direct assistant. The first leveling instrument was developed through their efforts in 1909, after Dr. Wild had invented the telescope with internal focusing[1] and constant length in 1908. For the refinements contained in this instrument, the astronomic designer was of little help, and Dr. Wild was forced to make his own designs.

Dr. Wild invented the cylindrical vertical axis which does not require adjustment, the biaxial telescope with reversible level, and the prism arrangement for split-bubble coincidence reading. The tribrach was also changed, and the foot screws were protected. Up to this time, these original levels were furnished with unsatisfactory tripods, but in 1909, Dr. Wild developed a new, stable, and lighter type of tripod which is still in use today. About that time, a first experiment was made with metal containers, but this was discontinued soon afterwards. A result of this first development on levels was an instrument of relatively high precision which did not cost too much and which was much lighter and allowed more flexibility and more accurate work. The best customers at that time for these new instruments were Argentina and Russia. It may be of interest to you to know that the estimated life span of an old-type instrument in Russia was 3 years.

The success of this new level caused the development of larger and more precise instruments, which are the fore-runners of the instrument of today.

The incentive for the creation of a better precision level had come also from the actual practice and experience of Dr. Wild. Around the year 1900, Dr. Wild had run first-order levels between Bienne and Neuchatel, two cities in Switzerland about 30 km. (20 miles) apart. At that time he used an instrument manufactured by Seibt-Breithaupt and a compensating rod. This was the latest equipment then available. It took approximately a month to cover those 20 miles and Dr. Wild had the opportunity to get first-hand knowledge of the clumsiness of the instruments then used in Europe.

During this leveling and in this relatively short distance, the tripod bolts had to be tightened 600 times; the rod read with a poor telescope 2,400 times; the instrument carried 600 times between set-ups; etc.

Dr. Wild was naturally interested in eliminating such handicaps. He already had the idea of the split-bubble centering which allows one to work with a centered level at all times and, therefore, he tried to improve the accuracy of the reading. He invented and developed the use of the optical flat in front of the objective lens to raise or lower the line of sight parallel to the optical axis, and

[1] The internal focusing telescope was in use by the Swiss Topographic Survey as early as about 1850 and was made by Lietz of San Francisco as early as 1890.—Ed.

connected the tilting motion of the optical flat to a glass scale in order to obtain an optical micrometer. This allowed a better setting of the reticle on the graduations of the level rod at all distances, and the commonly used horizontal hair of the reticle was replaced by a V-shaped line which facilitated reading the rod graduations more accurately and quickly.

Dr. Wild further found that the wooden level rods proved unsatisfactory for precise work, and so the graduations were marked on a special suspended steel tape.

The first of these new levels was used in the Fergana region located in Asiatic Russia, and it was soon found that in certain types of work, it was only possible to use this level with a much shorter tripod. Thus, the extension tripod came into existence.

With these types of precision levels, the greatest part of the first-order leveling of Switzerland was carried out. It was considered a special event when England purchased 24 of these instruments and with these instruments carried out the new first-order leveling in that country.

It was only natural that a great deal of resistance had to be overcome. One of the common complaints was that the large aperture of the telescope was detrimental to the accuracy of the measurement because too many "rays" would enter the telescope and cause "disturbances." A few years later, the first-order leveling of England was successfully completed with the new instruments under the supervision of this same critic. He was convinced of the superior quality of the large telescope objectives and, in the meantime, the objective lens had become even larger than the first development and the "rays" had submitted to the new development without causing any trouble.

In 1912 the construction of the modern theodolite was started. The first model was influenced by a large order placed by a customer abroad who had furnished a number of very rigid specifications; therefore, the instruments could only be partially modernized. However, it was possible to design the prototype of a completely new instrument prior to the outbreak of World War I. The war naturally stopped all developments, and only at the end of 1918 was Dr. Wild able to continue his research. He resumed his idea which had been developed since 1905, namely, the construction of a theodolite with simultaneous reading of coinciding, diametrically opposite points of the circle. A small instrument was built reading to 1 second and this was the actual start of the modernization of the design of the transits that had been standard up to that time.

During the war when the development was suspended, Dr. Wild severed his connection with the Zeiss Company in Germany and returned to Switzerland in 1921. At that time, the Henry Wild Surveying Instruments Supply Company was established at Heerbrugg, Switzerland. In reasonably close sequence, the new theodolites Wild T-2 and T-3 were designed and successfully accepted in the world market. After 1921 the development of modern surveying instruments progressed in Europe in the following manner:

1921—The Henry Wild Surveying Instruments Supply Company manufactured the first version of the Universal Theodolite Wild T-2 and the Precise Level N II.

1924—Zeiss introduced the Reduction Tacheometer invented by Bosshardt.

1926—Wild introduced the Precision Theodolite Wild T-3.

1928—Zeiss further developed the first Optical Theodolite invented by Dr. Wild and manufactured under the supervision of Professor Von Gruber, who was in charge of scientific development at Zeiss of the new Theodolite TH II.

1930—Wild introduced the Compass Theodolite T-O, the first and only compass theodolite in existence to-date.
1932—Wild added to their manufacturing program the Wild T-1 Double Center Theodolite.
1938—The original patent held by Dr. Wild on optical theodolites expired and other European manufacturers then entered the market and began the construction of competitive instruments of this type.
1940—German manufacturers made great strides in developing more modern instruments and a number of new manufacturers of such modern instruments entered the field.

The following listed firms are the manufacturers today of modern surveying instruments in Europe, or have been manufacturers previously, and whose reputations are well known:

Manufacturer	*Country*	*Manufacturer*	*Country*
Henry Wild	Switzerland	Ertel	Germany
Kern	Switzerland	Filoteenica Salmoiraghi	Italy
Zeiss	Germany	Galileo	Italy
Otto Fennel	Germany	Cooke, Troughton, and Simms	England
Hildebrand-Wiehmann	Germany	Watts	England
Askania	Germany	Miller	Austria
Breithaupt	Germany	Goertz	Austria
Dennert & Pape	Germany	Neuhofer & Son	Austria

As you will note, I have in front of me three instruments which represent the modern development and manufacturing ability of European precision workers today. The instrument to my right, the Wild T-12 Pocket Theodolite, with an accuracy of 1-minute vertical and horizontal circles, weighs a total of 7½ pounds, complete with tripod; the Filotecnica Salmoiraghi Optical Theodolite; and the newest development present for your interest, which has aroused a great deal of comment, the Zeiss Self-Leveling Level.

It gives me a great deal of pleasure to present these instruments for your attention as an indication of the progress and ability of the manufacturers in Europe who continually seek for better and more modern instruments to meet your demands.

American Surveying and Mapping Equipment

By CARL W. KEUFFEL
PRESIDENT, KEUFFEL & ESSER CO.

IN THE SHORT TIME AVAILABLE, I must confine my remarks to the fundamental instrument of the American surveyor—the transit. To illustrate this discussion I have brought along two instruments made by my company, an optical-reading theodolite and an engineers' transit. These instruments, I believe, typify the latest design in their respective fields. Both have interesting and important features.

Presented at Eleventh Annual Meeting, American Congress on Surveying and Mapping, Washington, D. C., June 18–20, 1951.

THE OPTICAL-READING THEODOLITE

The optical-reading theodolite features the short inverting telescope that is the starting point in the design of a small, light-weight instrument. It has an optical plummet that is used to check the position of the set-up when the wind is blowing. Three-screw leveling is provided to make leveling the instrument smooth and rapid. Most important of all, it has a glass circle and an ingenious optical train that enables the observer to read directly the average of both sides of the circle to almost any precision desired. Some of these instruments can be estimated to $\frac{1}{10}$ second.

THE ENGINEERS' TRANSIT

In an engineers' transit it is desirable to have a telescope with an erecting eyepiece and a focal length long enough to give good optics at a reasonable cost. It is also desirable to have a circle sufficiently large for accuracy and easy reading. These two elements establish the fundamental design of the engineers' transit. The instrument has a metal circle that does not change its centering with changes in temperature, as its coefficient of expansion is the same as the support on which it is mounted. The circle is read with the simplest (and most rugged) device—a pair of verniers. Although it is ordinarily read to 1 minute or 30 seconds, the circle can be read to about $\pm$ 6 seconds with 10-second graduations on the verniers. A four-screw leveling head is provided; this eliminates the slight rotations of the base that may occur with a three-screw leveling head when the fit of the leveling screws becomes worn. The four-screw leveling head also prevents the height of instrument from changing when the transit is leveled; this is important when the instrument is being used as a level.

Probably the most important feature of the engineers' transit is the double, tapered center. The taper gives an opportunity for a nearly perfect fit in manufacture, and the center automatically retains its fit as the shoulders wear. The inner and outer center makes it a true *repeating* center; when the upper clamp is set, the alidade and the circle turn together on a *single* bearing. There is, and there can be, *no relative motion*. Repeating clamps are sometimes used on the optical type of instrument, but, unfortunately, both the alidade and the circle of these instruments usually have separate bearings in the base. When the upper clamp is set, the alidade turns on one bearing and the circle turns on another. Any eccentricity between these bearings forces the alidade and the circle to rotate through different angles, as the point where the actual contact is made between the two parts moves through the same distance and therefore through a different angle with respect to each center. An eccentricity of 4/100,000 inch can introduce an error of 5 seconds when the contact point is $1\frac{1}{2}$ inches from the vertical axis. This is a systematic error that is added each time the angle is repeated. The American double repeating center is a remarkable device. It precludes the possibility of any such error occurring and being accumulated as angles are repeated.

THE CIRCLE

The heart of an instrument is its circle—and the accuracy of the circle depends on the dividing engine used to graduate it. The driving mechanisms of dividing engines with their connecting cams can be perfected almost indefinitely. But a dividing engine, like every machine, must have certain inherent errors. The limit of accuracy for dividing large circles is in the order of $\pm$ 1 second.

Smaller circles have more error, of the order of ± 2 to 4 seconds. When using an optical instrument, this error is reduced by measuring the angle on several different sectors of the circle and then taking the average. With the engineers' transit it is reduced by repeating the angle several times. For the optical-type method each reading must be very precise. For the engineers' transit, precision reading is not so important as the single final reading is divided by the number of repetitions.

FUNCTIONS OF THE INSTRUMENTS

Vertical Angles

So much for what these instruments are like, let us see what they will do. Star altitudes and other vertical angles can be measured more accurately with optical instruments. These angles can be read with more precision, and the index level makes them more accurate. Only one position of the circle can be used on either instrument and neither will repeat.

Triangulation

The optical-reading theodolite is much faster for triangulation where many directions are measured from one set-up. Only one pointing and one reading are required for each direction for each circle position. With the engineers' transit two pointings are required for each direction for each repetition. To obtain the same accuracy, approximately 50 percent more repetitions than circle positions are required for instruments of the same class.

Traverse Angles

The above comparison does not hold true for traverse angles when only two directions must be observed. *Two* pointings are required for each direction for *both* instruments per circle position or repetition. Even though 50 percent more repetitions are required with the engineers' transit, the much greater number of readings and the subsequent arithmetic required for the optical theodolite militate against it to such an extent that little, if any, time is saved.

Stadia

The two instruments are of course identical for stadia measurements. The higher precision of the vertical angles measured with the optical instrument improves the accuracy of the elevations. But, without a proper repeating system, it is not practical to set the alidade at a given azimuth reading. This prevents using the same azimuth base for all stadia stations. With an engineers' transit it is possible to set the back azimuth for each backsight and thus to orient the instrument in the same direction at all stations. The recorded azimuth for every stadia shot is then the same everywhere and considerable time is saved in plotting.

Running Levels

As every practicing engineer knows, there is a great practical advantage in being able to run level lines with the transit. It makes surveying parties more flexible and saves many hours during the year. Level lines can be run with an optical instrument, but the operation is so difficult and slow that it is impractical.

Giving Line and Grade

Here in Washington, where the great Government surveying bureaus have their headquarters and many of the advances in surveying techniques are con-

ceived and developed, discussions generally turn to the vast surveying projects that these bureaus are carrying out. It is probable, however, that 60 to 80 percent of the surveying man-hours of the country are spent in a type of surveying in which these bureaus seldom engage. I speak of "giving line and grade"—the location survey.

Surveying is being used more and more in modern construction operations. Economies require an accurate survey for the proper coordination of the work. The more the line and grade can be controlled by surveying techniques, the more the different parts of the work can be accomplished simultaneously. Once a construction project is initiated, it becomes a race with time to reach the point when revenue will accrue from the expenditures. For "giving line and grade" nothing surpasses the engineers' transit.

Alignment

The basic operation in staking out work is setting a stake and a tack on line. Here the long telescope and the erecting eyepiece of the engineers' transit are important assets. First, the stakeman must be brought into the field of view. The transitman judges the position of the field of view by looking along the top of the telescope. The longer the telescope the more easily this can be accomplished. The optical-reading theodolite has open sights for pointing, but it is difficult to use them without bringing the eye so near the telescope that the movements of the stakeman are obscured.

Once a stake or a plumb bob has been brought into the field of view, observations are made through the telescope. If the telescope is inverting, the transitman must reverse the directions he has first been giving to produce the same apparent movements. This is difficult and frustrating and usually wastes a certain amount of time.

Setting of an Angle

In construction work, innumerable 90° angles must be set off. The process is to set the vernier at zero for the backsight and to turn 90°. With an optical theodolite it is necessary to *read* the direction of the backsight and then to apply a correction to the 90°. This is time consuming and likely to introduce error.

To stake out a curve it is necessary to set the vernier at zero or at a given deflection angle for every backsight. When the curve turns to the left, counterclockwise deflection angles are used. Both the circle and the vernier of the engineers' transit can be read counterclockwise as well as clockwise. This is a great convenience. A curve can be staked out with an optical theodolite, but it takes plenty of mental gymnastics.

Giving Grade

The value of the telescope level on an engineers' transit is especially noticeable in laying out construction. Line must be given here, grade there. A field party ready to do both is a great asset. In giving grades, of course, the erecting eyepiece is important. The rod target must be brought into the field of view and then observed through the telescope. The erecting eyepiece eliminates the necessity for reversing the signals.

CONCLUSION

It seems apparent that an optical-reading theodolite is a superb instrument for the purpose for which it was designed—triangulation. It is light, fast, easy

to read, and easy to level. With proper manipulation it will give results of a high order of accuracy.

On the other hand, the engineers' transit is a *universal* instrument that will perform every surveying operation except triangulation and perhaps the measurement of traverse angles as well as, or better than, an optical theodolite. Even these operations can be performed just as accurately as with an optical theodolite, although triangulation work will take slightly longer. For giving line, for setting grades, for laying out angles, and for staking out curves, in fact for the thousand and one surveying operations which occupy the major portion of the time of the field party, the engineers' transit is unsurpassed.

Every engineer knows that, in the course of time, cleaning, minor repairs, and adjustment are required by every instrument. The engineers' transit is so simple that a repairman competent to do this can be found in almost any city of reasonable size. When this type of work has to be done on an optical theodolite, it usually means that the instrument has to be shipped back to the factory or a repair depot.

These are the reasons why the engineers' transit is preferred by the average American engineer.

* * *

International Geographical Congress

THE EIGHTH GENERAL ASSEMBLY of the International Geographical Union and the Seventeenth International Geographical Congress will convene in Washington, D. C., from August 8 to 15, 1952, according to a recent announcement by the National Academy of Sciences–National Research Council, which adheres to the I.G.U. on behalf of American geographers. Approximately 1,500 delegates, representing more than 30 countries, are expected to attend.

Arrangements for the meetings have been underway for more than 2 years by the U.S.A. National Committee of the I.G.U., headed by Dr. Wallace W. Atwood, Jr., executive secretary of the Research Council's Division of International Relations. A headquarters office for the National Committee was recently established at the Research Council and Dr. Walter W. Ristow appointed executive secretary. Dr. Ristow is on leave from the Library of Congress, where he is assistant chief of the Map Division.

The I.G.U. is one of nine constituent organizations of the International Council of Scientific Unions, established to promote international cooperation in science. Thirty-one nations adhere to the I.G.U. Its purposes are to promote the study of geographical problems, initiate and coordinate research projects requiring international cooperation, facilitate discussion and the exchange of ideas on an international basis through periodic meetings, and maintain commissions to study special matters which arise between Congresses.

The Seventeenth Congress will include sectional meetings for the presentation of papers in the several principal fields of geographical science. General sessions will also be held for the discussion of special topics of world-wide interest and reports on research activities of the various commissions of the Union. The program will provide opportunity for the free exchange of ideas among geographers of all countries and will emphasize those areas of investigation which can be furthered through international cooperation. The meetings will be held in the Hotel Statler, which has been designated as Congress headquarters.

The Role of Surveying and Mapping in National Defense

By BRIG. GEN. HERBERT B. LOPER
CHIEF, ARMED FORCES SPECIAL WEAPONS PROJECT

I HAVE BEEN INDUCED by your president to discuss the role of surveying and mapping in national defense. Although I appreciate the privilege of addressing you on the subject, I find it impossible to say anything that you don't already know. I am tempted to report to you simply that "mapping is important to the national defense," and then we can all go out for a short beer before the next speech.

There are as many concepts of what is important to national defense as there are people who are willing to discuss the subject—approximately 50 million; and there are as many ideas as to the relative importance of the various things as there are Federal, State, and local Government agencies—approximately the same number. We have heard important people proclaim that this or that is the most important thing to national defense and that something else is not important at all. The Honorable A says UMT [Universal Military Training] is the thing; the Honorable B says buy more bonds; Honorable C says grow more spinach; and Honorable D, who hold some soap stock, says use Lifebuoy and the enemy won't know you're coming. In all these pronouncements I have yet to hear any authority claim that mapping is not important to national defense. Hence, I think we may take justifiable pride in our profession, because if it were not important someone would surely say so. Having thus conclusively proved that mapping has a role in national defense, I think we may develop, in the next 3 hours, just how far up or down on the list of national defense star players it stands.

War has become a highly specialized and industrialized business. It is industrialized in that it requires and employs a high percentage of our total resources in raw materials and the utilization of a great percentage of our highly complex manufacturing and distribution systems for the production of munitions. It is specialized in that it requires expert application of the products of our industry when and where they will have maximum effects. Everything that contributes to our industrial strength adds to our strength in national defense. Our ability to apply this industrial strength to military uses is our greatest asset in the defense of our country and our institutions against the greater masses of manpower arrayed against us. As has been so well pointed out by the preceding speakers, mapping is essential to the development of the economy of nations; and, as Mr. Robert H. Randall has adequately stated, it adds also to our national strength through the close ties it cements with our friends of the Western Hemisphere. Consequently, it is not possible to refer to the role of mapping in national defense in the narrow sense of military mapping. Mapping for the development of our industrial, economical, and cultural resources and military mapping are merely complementary—the one develops the muscles, the other applies them.

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We are prone to regard our industrial potential as our greatest element of superiority over the Communist nations. The atomic weapon, with which I happen to be associated at the present time (one always gets in a plug, if possible), is the most outstanding example of scientific and industrial capacity yet manifested by man. It is also the greatest destructive force created by man. In many ways it represents, more than any other thing we produce, the cumulative effort of our industry in preparation for war. Unlike other weapons, the essential ingredients of atomic weapons do not deteriorate with time. The ability to store or accumulate this powerful fruit of our amazing industry has given us an advantage not normally possessed by a peaceful nation. One outstanding advantage is that it enables us to maintain a considerable measure of military strength even in a state of almost complete disarmament, as we were from 1946 to 1948, compensating in part for an aggressor nation's ability to select the time and place to further its aggressive policies by force. In the past we have depended on the strength of our allies to give us time to mobilize our industrial and military strength. Following World War II, we have had no strong allies to give us that cushion of time. There are many who believe that the enemy would have struck swiftly and surely during our period of apparent greatest weakness had he not known that we possessed the great destructive force of atomic weapons and *the ability to deliver them.* The key words of this message are, of course, "the ability to deliver," for no weapon, however powerful, is a menace on the shelf or in an igloo; and the best system of delivery man can devise is useless without guidance to the spot where its effects are required. Thus, mapping is the first essential to the development of our economy and industry, which are our defensive strength, and the last essential to the military application of that strength when circumstances make it necessary to pursue such a course of action.

I have used our capacity to produce and develop atomic weapons as an outstanding example of the importance of the role of surveying and mapping to the development and application of our defensive potential. I might just as well have used the .30-caliber rifle and the intrepidity of our soldiers as an example because the principles involved in preparation and delivery are the same.

In a peaceful nation the military mapper has a tough job. He cannot select his time and place to fight or, if he can select it, he is usually not free to map it. The mapper must take his cue from the strategist, who at best can only say where we *should* fight, but cannot say with certainty either where or when we will fight. Sometimes the mapper is the better guesser of the two. As evidence, I point to the scene of our present war, which the strategists have insisted for many years is no place for us to fight. Yet, due to a bit of foresight, or second guessing, Korea was established as the first priority for a rather extensive mapping program undertaken by the then War Department in 1945. If we should undertake to examine the history of that program, I expect we would discover that the decision to head the list with Korea was not made by an outstanding military strategist; more than likely it was made by a relatively junior mapping officer sitting in a somewhat obscure corner of the Pentagon.

I would not have you conclude from such an isolated example that the selection of objectives for military mapping is a haphazard affair, governed by the whims of individuals. On the contrary, mapping programs are based on the general national plans of the National Security Council and the detailed plans prepared by the Joint Chiefs of Staff pursuant to that guidance. To the maxi-

mum extent possible, mapping programs are prosecuted to meet the requirements of those plans. It frequently happens, as in the case of Korea, that an apparently remote possibility, coupled with an existing opportunity, justifies a departure from the more logical order of priorities. By the same token, we must remain alive to every opportunity to extend our knowledge of the physical characteristics of the earth's surface. Furthermore, we must continue to extend that knowledge to the earth's atmosphere and stratosphere and to the characteristics of its seas, surfaces, and depths. We cannot know with certainty what form or direction an attack will take, nor where our defenses will be. Mapping, therefore, as an instrument of national defense cannot be circumscribed by definitions which would place it in a distinct or isolated category related only to movements and operations on a battlefield. On the contrary, its role is as broad and all inclusive as is our total capacity to maintain our national integrity.

* * *

Nautical Tables Accurate

NAVIGATORS OF SHIPS AND PLANES traveling near the North and South Poles, and those who must use the sun and moon and stars and planets near the horizon for their calculations, can now rely with confidence upon the refraction tables in their nautical and air almanacs.

Within the past year navigators of 33 ships have made 315 test observations that confirm the accuracy of standard values adopted for the refraction of light passing through the earth's atmosphere, G. M. Clemence, director of the U. S. Nautical Almanac Office at the Naval Observatory, reported to a recent American Astronomical Society meeting in Washington.

If there is any error in the theory of refraction at great zenith distances, it is so small that the calculated position of a ship would be only a few tenths of a nautical mile off, Mr. Clemence said.

Light from the sun, moon, planets, and stars is often bent so much by the earth's atmosphere that we see these celestial bodies slightly displaced from their true position in the sky. Overhead light enters the atmosphere almost perpendicularly and is therefore refracted little, if at all. For this reason navigators prefer to make their celestial observations high in the sky.

At the horizon, however, the light enters the atmosphere at an angle and passes through much atmosphere, thus causing a great apparent displacement. The sun, for instance, is actually visible shortly before it reaches the true horizon in the morning, and a star can be seen when it is really below the true horizon. Thus, close to the horizon, the apparent change in position must be taken into account in fixing the location of a ship or plane.

To make the test observations, each navigator at dawn or dusk determined his ship's position by observing stars at least moderately high in the heavens and thus little affected by refraction. Then, with his sextant the navigator measured the actual and uncorrected altitude of the rising or setting sun. Back at the Nautical Almanac Office this measurement was compared with the sun's calculated altitude based on the position of the ship, and the figures were found to agree admirably.—*Science News Letter*, July 7, 1951.

Accuracy in Land Measurement

By JOSEPH F. HEATON
WASHINGTON, D. C.

THE WRITER was for some years an assistant valuer in the Government Land Valuation Department, in England, and the conversion table herewith was compiled for the purpose of converting acres and decimal parts thereof to acres, roods, and poles, and vice versa. The table makes it possible to subdivide, for example, 3.925 acres to acres, roods, and poles more accurately, because 1 pole is equal to 1/160th part, or 0.00625 of an acre. I have seen American maps giving areas to 1, 2, and occasionally 3 places of decimals, which obviously leads to inaccuracies as:

If given to	1	decimal	place	or	1/10th,	the	error	could	be	484	square	yards
"	"	"	2	"	"	"	1/100th,	"	"	"	"	48.4	"	"
"	"	"	3	"	"	"	1/1000th,	"	"	"	"	4.84	"	"

It is clear therefore that if part of an acre is given to only 1 decimal place, the possibility of error is 484 square yards, and when applied to small areas, this becomes serious.

The following conversions are given to make clear how yards, chains, and poles are used in a practical way to arrive at the acre or parts thereof.

Lineal Measure

1 pole, rod, or perch = 5½ yards or 16½ feet
4 " " " " = 22 " " 66 feet = 1 chain

Square Measure

		1	square	pole,	rod,	or	perch	= (5½ × 5½)	=	30¼	sq.	yds.	= 1/160	acre
1	rood	=	40	"	"	"	"	= (40 × 30¼)	=	1210	"	"	= ¼	"
2	"	=	80	"	"	"	"	= (80 × 30¼)	=	2420	"	"	= ½	"
3	"	=	120	"	"	"	"	= (120 × 30¼)	=	3630	"	"	= ¾	"
4	"	=	160	"	"	"	"	= (160 × 30¼)	=	4840	"	"	= 1	"
				1	square		chain	= (22 × 22)	=	484	"	"	= 1/10	"
				10	"		"	= (484 × 10)	=	4840	"	"	= 1	"

There are 10 square chains to the acre, and as this measurement by the chain is the recognized practical method, by hand, it seems logical to assume the square chain, which equals 1/10th of an acre, is the proper unit to adopt when subdividing the acre.

There are 4 poles to 1 lineal chain, 16 square poles to 1 square chain, and 160 square poles to the acre.

Example: To find the equivalent of 3.925 acres converted to acres, roods, and poles, ignore acres for the time being, and select the nearest decimal figures below .925 which are as follows:

				Acres	Roods	Poles
.875	acres	equals		0	3	20
.050	"	"				8
3.925	acres	equals		3	3	28

Example (inverse): To find the decimal equivalent of 3 acres, 3 roods, and 28 poles:

Acres	Roods	Poles
3	3	20 = 3.875 acres
		8 = .050 "
3	3	28 = 3.925 "

Conversion table for topographic and plat maps
(From acres and decimal parts to acres, roods, and poles, and vice versa)

Acre	Poles	Acre	Roods	Poles	Acre	Roods	Poles	Acre	Roods	Poles
0.00625	1	0.25625	1	1	0.50625	2	1	0.75625	3	1
.01250	2	.26250	1	2	.51250	2	2	.76250	3	2
.01875	3	.26875	1	3	.51875	2	3	.76875	3	3
.02500	4	.27500	1	4	.52500	2	4	.77500	3	4
.03125	5	.28125	1	5	.53125	2	5	.78125	3	5
.03750	6	.28750	1	6	.53750	2	6	.78750	3	6
.04375	7	.29375	1	7	.54375	2	7	.79375	3	7
.05000	8	.30000	1	8	.55000	2	8	.80000	3	8
.05625	9	.30625	1	9	.55625	2	9	.80625	3	9
.06250	10	.31250	1	10	.56250	2	10	.81250	3	10
.12500	20	.37500	1	20	.62500	2	20	.87500	3	20
.18750	30	.43750	1	30	.68750	2	30	.93750	3	30
.25000	40	.50000	2	00	.75000	3	00	1.00000	4	00

Let me put in a word for the careful and conscientious surveyor who feels he owes it to his successor to leave things at least "so-so" to earn a passing reputation for the good of the profession. I am afraid what may be called "good-enough" now will at some future time be frowned upon. Having too much land in the larder, as it is, it should not be taken for granted because of that abundance; it may somehow get into the other man's hands eventually. Surveyors will understand why foresights and backsights should balance, or there is something amiss! Why should not this same principle apply to land measurements?

Two Historical Stones Found Under Old Naval Hospital

WRECKERS TEARING down the old Naval hospital at 23rd Street and Constitution Avenue (Washington, D. C.) uncovered two mementoes of early American history—Braddock's Rock and the Key of All Keys.

The rock is the one on which British Gen. Edward Braddock is supposed to have camped April 11, 1755, before embarking on an ill-fated campaign of the French and Indian War.

The Key, marked by a small stone, is the central point from which Alexander Beall, clerk of the town of Georgetown, began his survey of the town's original 60 acres in 1751.

Originally, the rock was a ledge which stood out prominently on the banks of the Potomac. Later the river channel was changed, and the rock was covered with filled-in land.

Workmen were on the lookout for both the rock and the key. There was a clause in their contract which stipulated that the historical objects were to be protected.

The Problem of Control for Topographic Mapping in Northern Canada

By LIEUT. COLONEL C. H. SMITH, R.C.E.
DEPUTY DIRECTOR OF MILITARY SURVEY, ARMY HEADQUARTERS, OTTAWA, CANADA

CANADA HAS APPROXIMATELY THE SAME AREA as the United States including Alaska but only about a tenth the population. Other things being equal then, we must make 10 times the expenditure per capita to map our country. However, it is a matter of scientific fact that others things are not equal; for our climate is much less temperate, and our transportation facilities are restricted to a comparatively small proportion of the country. Therefore, apparently, we should spend considerably more than 10 times as much per capita on mapping as you do in this country. Consequently, the problem we encounter at the outset is that of having to "make do" with much less money than we would like to have.

If we assume that eventually the whole country is to be covered on a large scale and that time is not a factor, the economical procedure would be to carry out the large-scale work first and produce small- and medium-scale maps from this basic mapping. Unfortunately, time is of the essence, and it would be ridiculous to say that we must do without maps of any kind of northern Canada until such a time—possibly 100 years hence—when an over-all large-scale mapping project covers the country. In view of our large country and small population, we are therefore forced to depart widely from the ideal of a basic topographical map in order to satisfy the minimum requirements of our generation.

Our mapping policy is based on our capabilities, both financial and technical, as well as on our requirements. It aims at small-scale (1:1,000,000) coverage as an immediate objective and at complete medium-scale (1:250,000) mapping within 10 to 20 years, together with large-scale (1:50,000 or 1 mile = 1 inch) coverage of certain routes and limited areas which are of particular importance for defense or development.

Our requirements for field work emanate from this policy. Adequate control for small-scale maps has been established, largely by astronomical observations, over the entire mainland of Canada and is being extended well into the Arctic Islands. Our immediate task is the provision of control of third- or fourth-order accuracy, covering the whole of northern Canada for medium-scale mapping, and of second- or third-order in areas slated for large-scale mapping.

THE PROBLEM OF CONTROL

One of our principal difficulties in the North Country stems from the fact that our primary geodetic control lags behind our mapping needs. In fact, the huge expenditure involved in extending work of geodetic accuracy across a country deficient in means of transport and, except in mountainous areas, requiring a tower for practically every station, had all but prohibited any further extension. In recent years, however, we have had high hopes that the Shoran line-crossing method would provide the means for rapid establishment of first-order control throughout the North. But, even though the feasibility of the method

has been fairly well established, it has not yet been sufficiently developed to permit us to forecast the rate of progress with any degree of certainty.

In practically all our northern work, the datum is based at best on extended second-order triangulation or traverse and at worst on a local astronomical fix. We accept the fact that ultimately nearly all large-scale mapping will require revision of its horizontal position. However, we hope that this adjustment will in most cases be insignificant at medium and small scales.

In extending second-order control into the North we encounter problems which vary with the geographical features of the country. For our purpose we may consider three very broad geographical regions: the mountains of British Columbia and the Yukon, the great central plain which has comparatively few lakes, and finally the Precambrian Shield where lakes cover almost 20 percent of the area.

The mountains present the least difficulty. Here triangulation is always possible, and here too we have reasonably satisfactory methods of transportation.

The pack horse is still the basic transportation medium in the mountains; he is slow and expensive but nonetheless effective. Normally, a party operates with about 12 horses for distances up to 50 miles from advance bases on lakes, where supplies are flown in every 3 or 4 weeks. Use of the pack horse permits transportation of reasonably adequate accommodations and supplies and the location of the camp within climbing distance of each triangulation station. However, despite his advantages, the horse is in imminent danger of being driven out of this, practically his last, stronghold against mechanization. The helicopter threatens to replace him.

To everyone who has struggled up mountain after mountain with an instrument pack on his back, the helicopter seems to be the panacea for all the ills that beset the field engineer. Unfortunately, as with most innovations, the helicopter presents its own peculiar problems. It is expensive, its capacity is quite limited, especially at high altitudes, and good pilots are hard to find. Nevertheless, it is apparent that, as its teething troubles are overcome, it will encroach further and further into the domain of the pack horse.

While our employment of helicopters during the past two seasons has been more or less experimental, this year we have based several operations on helicopter transportation. In one area which we consider favorable, a party using a helicopter will establish control for 8,000 square miles of 1:50,000-scale mapping this summer. Without the helicopter the officer in charge could expect to complete, at best, 800 square miles; hence, as a means of increasing the production of our relatively few well-trained topographical engineers, the helicopter is an outstanding success. In the matter of unit costs, however, the advantage is not so striking. We expect that with reasonable luck the tenfold increase in output will increase the over-all cost only eight times. We do feel though that, as helicopter operators gain experience and as competition increases, prevailing charter rates will be substantially reduced, particularly in view of the present trend toward cheaper and more efficient aircraft.

In our triangulation we follow American practice, so I need not bore you with details. In one respect, though, I believe we differ, and that is in the use of terrestrial photography. The extensive use of ground photography in the Canadian mountains antedates the vertical air photograph by many years. Originally it was an expedient, dictated by our short season, to reduce the field

time required for planetabling at the expense of more time for office compilation. With a similar object we now take horizontal photographs at each triangulation station and use them to intersect supplementary horizontal control and extend vertical control to identifiable points of detail on air photographs. In medium-scale work we use heights so established for contouring vertical airphotos under the stereoscope. In large-scale mapping we use these spot-heights to control the multiplex model.

TRANSPORTATION AND FIELD WORK

In the northern part of the Great Plains and in our other flat areas of the North, we encounter problems entirely different from those of the mountains. Here triangulation is definitely impossible and traverse is the only method at present available to us. Much of this area is wooded so that traverse involves line cutting, which tends to be both slow and expensive.

Due to the muskeg, an ubiquitous condition that prevails over hundreds of thousands of square miles, travel during the summer is possible only by air or along main waterways. Muskeg is swampland characterized by springy moss or clumps of grass interlaced with water, which is held on the surface by impermeable underlying rock or permafrost. Muskeg may be lightly wooded, covered with brush such as willows, or completely open. It is impassable to horses and to most tracked vehicles and practically impassable on foot. True, it can be navigated by very light, semi-amphibious vehicles with extra broad tracks, but these are costly and are easily wrecked on the rocky ground that separates the areas of muskeg. Under these conditions, it is obvious that survey work is not feasible during the summer and that the only possibility lies in winter work.

During the boom days of the early part of this century, land subdivision was pushed well into the North with winter work. It was a tough life, clearing line with ax crews at below zero temperatures, living in tents, and receiving supplies by dog team; but many hundred miles of line were run in this way. We are more fortunate today in that we can obtain supplies by air and use caterpillar tractors for transportation and for cutting lines.

At least two major survey operations have been successfully carried out in this way. The first was in the Churchill area of Hudson Bay where traverse control for two 1:250,000-scale sheets was established in 1947. This job was straight forward in that the terrain was largely open Barren Lands which did not require line cutting. At first we attempted to use light over-snow vehicles or snowmobiles. These had the doubtful advantage of speed, but they tended to create more problems than they solved. Fuel supply had to be dropped by air, maintenance was difficult, and the vehicles provided no shelter for the party. On the other hand, the tractor train, with its cabooses for office and living accommodations and its open sleds carrying up to 20 tons of fuel or provisions, undoubtedly provides almost ideal transportation for a winter survey party.

Last winter we extended the use of the survey tractor train to the timbered muskeg country of northern Alberta, where the tractor, rigged as a bulldozer, performed the additional task of line cutting. The heavy equipment in this case consisted of two D8 Caterpillars, two cabooses, and two freight sleds. Four thousand gallons of fuel were carried. It was found that, in moderately light timber, a rate of 4 to 7 miles per day could be maintained. By streamlining the sleds so that a narrower line would suffice, this progress could be improved and

it should be possible to move at the best rate that the traverse party can maintain, say 10 miles per day.

However, the dog team is still used in our winter operations when the ground is too rough for cross-country travel and the only feasible routes lie along the rivers where the heavy tractor may come to grief on thin ice. On one such project last winter in northeastern British Columbia a party consisting of seven men and four dog teams accomplished 348 miles of traverse in the 2½-month working season.

Generally speaking, survey work is not seriously hampered by moderately low temperatures of 20° or 30° below zero. Men, properly clothed, can carry out the operations pertaining to traverse with an efficiency that compares quite favorably with summer work. It is questionable whether low temperatures reduce efficiency much more than does the plague of flies and mosquitoes that inevitably accompanies warm weather in the North.

In our third type of country, the huge area of the Precambrian Shield, the topography is rough and rocky with an abundance of lakes and small muskegs. The relief is not great but, north of the tree line at least, triangulation is generally feasible. Up to a point transportation is relatively simple, since a float-equipped plane can land on any of the larger lakes. On the other hand, travel between the lakes is anything but easy, and as a result little control has heretofore been established. However, surveys for large-scale mapping were begun last year in the great new iron ore areas of northern Quebec.

The survey party used a conventional airplane and a helicopter. Camp was moved and supplies freighted in by airplane, and the surveyors were carried to the triangulation stations by helicopter. The operation was a success and control was established over some 7,000 square miles in 29 flying days. It is felt that this sets the pattern for future work in the Shield area.

USE OF MULTIPLEX

Although any discussion of control for topographical mapping tends to deal with field work, it is, of course, impossible to separate field and office into water-tight compartments. The amount of work in the office can often be substantially reduced by additional work in the field and, conversely, extra office work will sometimes permit a reduction in field work. Since we find field operations the most expensive item in map production, we carry office work as far as possible. For 1:250,000-scale mapping we have extended control, by multiplex bridging, up to 20 overlaps and, with the Wild Autograph equipment, we hope to increase this figure substantially.

We use bridging in two ways. First, we employ it as a standby. This permits the field man to reduce his work to a minimum with the assurance that, if he underestimates the amount required, ground control can be supplemented by photogrammetry. Secondly, we use bridging as a deliberate method of extending control over inaccessible areas. We are presently working on a 1:250,000-scale project in which control is extended by multiplex traverse, which, in turn, is controlled for altitude, azimuth, and scale at intervals in its course. These scale checks consist of short transit and tape traverses and solar observations at suitable spots along the route of the multiplex traverse. These are accomplished by carrying a party by helicopter to the only feasible landing spots, gravel bars which appear in rivers at their low-water stage. Elevation checks are made by barometer.

Obviously, this procedure could not be extended indefinitely, but our experience indicates that, using multiplex with at least one scale and elevation check in each "traverse leg," it should be possible to carry traverse (or "aerial triangulation," to use a more exact term) for a maximum of 3 courses averaging 17 overlaps each and to achieve an accuracy suitable for 1:250,000-scale mapping.

In our northern work to date we have been able to use conventional methods, modified where necessary to suit local conditions and modern methods of transportation. But as our mapping program expands we are rapidly working into territory where these will prove inadequate.

SHORAN AND DECCA

The requirements of speed indicate that some form of electronic surveying instrument may be the Moses most likely to lead us out of this control wilderness. Already we are fairly well convinced that Shoran provides the most effective means for the rapid extension of our primary net with an accuracy which, if not quite up to geodetic standards, at least meets our present requirements. But the measurement of distances by line crossings, which involves the establishment of ground stations at both extremities of each distance to be measured, is too expensive and cumbersome to be used when the triangle sides are under 50 miles in length. The final breakdown into third-order control, dense enough for medium-scale mapping, must be accomplished in a simpler manner.

Shoran-controlled photography is one promising method which we have investigated. Fixing the aircraft's position in space at the exposure instant is a comparatively simple matter, but accurately tying this fix to the ground requires the determination of tilt which, in turn, necessitates some vertical control.

A single, fairly comprehensive, test of the Shoran method indicates that, using long multiplex extensions with vertical control at both end of each extension, we can establish horizontal control accurate enough for 1:50,000-scale mapping. Given such control along every fifth flight line only, we can map to 1:125,000-scale standards and, with no additional vertical control, still produce acceptable 1:250,000-scale planimetric maps by substituting the principal for the plumb point.

In all three cases we require at least one horizontal fix in the area controlled from a pair of Shoran stations in order to avoid the possibility of a constant position error due to faulty instrument calibration or local reception conditions.

Another electronic method which we hope to test next fall is Decca, a long-wave system of British design which is extensively used in Europe. Unlike Shoran, it will operate efficiently without a clear optical path between sender and receiver; and, since the receiver weighs less than 40 pounds, the station to be fixed can be moved by car, canoe, pack horse, or other ground transportation. In areas where ground travel is feasible we can therefore avoid the problem of transferring the air fix to the ground. It is claimed that Decca fixes have a position error of only 1 in 5,000 for distances up to 100 miles. If this is correct, they provide control well within the requirements of medium-scale mapping. However, a decided disadvantage of this method is that it requires the use of three transmitting stations, and for maximum efficiency their relative positions are somewhat restricted.

Vertical control must keep pace with horizontal. We have reason to hope that the radar altimeter will eventually provide the answer to this problem. This instrument was developed in Canada for the purpose of providing vertical

control of an order accurate enough for 1 : 500,000-scale mapping. It proved so successful that further experiments are being conducted with a view to obtaining increased accuracy.

Actually the radar altimeters now available give a graphical record of the vertical interval between the aircraft and the ground with an average error of about 25 feet. Hence, the absolute accuracy of the ground profile depends largely on the accuracy with which we can establish a profile of the aircraft's flight path.

The latter is determined from pressure altimeter readings corrected for temperature, instrumental errors, and any changes in atmospheric conditions occurring during the elapsed flight time. The problem thus becomes more meteorological than electronic. An empirical formula based on air speed, distance flown, drift, and latitude gives an approximate height correction for atmospheric change, but the general solution of the problem awaits the establishment of sufficient weather stations in Canada to supply the data necessary to draw precise pressure contours of the upper air. On the other hand, given only a few known elevations (preferably lakes or flats), the flight profiles covering large areas can be readily adjusted to sea level by routing the aircraft over the known heights at fixed intervals.

In evaluating the results of experiments to date with electronic control, speed and accuracy rather than cost have been the governing factors. But, given sufficient work to keep the electronic equipment continuously employed during the normal field season, there is no doubt that its use would considerably reduce the unit cost per square mile.

The Value of Brevity

TEACHERS OF MODERN WRITING consider brevity and plain language a prime requisite, and it is continually stressed. Possibly of even more importance, the editors of our national publications demand it. The wordy manuscript, filled with the worst from Webster, is returned so fast to the amateur writer that he thinks there is a plot against him in the magazine's mailing room.

I recall my unhappy introduction to the value of brevity while attending a college class in creative writing. I had just completed reading my first manuscript, a windy affair filled with beautiful phrases, and had returned to my seat. With my head bowed, I sat in blushing modesty, waiting for the words of praise to fall from the lips of our crusty professor. The class was silent as they waited like Russian puppets for the professor's reaction before declaring themselves. The professor, a picture of suffering patience, tapped the top of his desk with a pencil and sighed softly—the only noise to break the quiet expectancy that filled the room. Finally, he spoke. "It would seem," he said, "that Mr. Dewey is fascinated with the sound of his own voice."

. . . The point behind the professor's remark can be found in any national magazine. Note the brevity and simple sentence construction. Every word must lend itself to the story or become a candidate for the editor's blue pencil.—Extract from "How Does Your Correspondence Read?" by Chief Engineman Howard S. Dewey, *U. S. Naval Institute Proceedings*, February 1951.

The "River of Doubt" and Brazil

By CLAUDE F. GILCHRIST
AERONAUTICAL CHART AND INFORMATION SERVICE, USAF

RIO DA DUVIDA, (River of Doubt), was the name of the swollen torrent of water that disappeared northerly into the dense Brazilian jungle. This river was first discovered near its source by an expedition which crossed it while surveying for a telegraph line. The only thing about this river known to the men, constructing the telegraph line between Cuiabá and Pôrto Velho, was that it must eventually empty into the great Amazon, approximately 700 miles north. No man had ever attempted to determine its course or extent, but it was believed to be quite long, and wide near the mouth. Geographers of the day had never even heard of it and maps were compiled accordingly.

It was in 1913, a few years after the first crossing of the "River of Doubt," that "Teddy" Roosevelt accepted invitations to address various organizations in Brazil and Argentina. From this trip grew the legendary "Expedição Científica Roosevelt-Rondon." "Teddy," instead of returning to the United States by normal routes at the completion of his lectures, decided to organize an expedition to travel up through the middle of Brazil into the valley of the Amazon. It was only natural that he heard about the mysterious "River of Doubt," and quite understandable why a man of his nature jumped at the opportunity to explore this unknown stretch of Brazilian water. As this area had never been covered by collectors, he invited naturalists to accompany him. The American Museum of Natural History, hearing of his ambitious plans, sent along two.

In Brazil "Teddy" was to join forces with a Brazilian Colonel, a man whom he later described in one of his books as a gallant officer, a high-minded gentleman, a peculiarly hardy and competent explorer, a good field naturalist and scientific man, a student, and a philosopher. This man is better known today as General Cândido Mariano da Silva Rondon, "Grand Old Man" of Brazil. At the venerable age of 85 he still heads the Conselho Nacional de Proteção aos Índios (National Council for the Protection of Indians). He has held this post continuously since before the Roosevelt-Rondon expedition in 1914. To this day he is loved and respected by the thousands of Indians he has encountered during his many interior trips, due primarily to his great patience and understanding of these primitive people.

I had the good fortune to confer at length with this "Grand Old Man" of Brazil. When in conversation with General Rondon, I inquired as to his feelings toward Roosevelt. His face lit up and he seemed to reach far into his memories and told me of the many pleasant talks between them and how they seemed to reach a complete understanding though neither spoke the other's tongue. They were both fairly conversant in French and so used this language as their medium.

At the time he was chosen to represent Brazil on the expedition, General Rondon, part Indian by birth, had already spent 24 years in the Brazilian

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jungle surveying and mapping rivers, constructing telegraph lines, and establishing good relations with the numerous tribes of Indians. General Rondon relates that the only way he could obtain funds to open the interior was to sell his government on the necessity of constructing telegraph lines. In fact, his primary purpose of joining the expedition was to further the opening of the interior by making a survey of the river as they progressed.

SURVEYING AND MAPPING IN THE BRAZILIAN JUNGLE

"Teddy" and his party began their leg of the trip to Buenos Aires and traveled up the Paraná River into the Paraguay River, reaching Corumbá, Brazil, where they joined General Rondon and his party. Then the expedition continued northward up smaller rivers and overland to the head of the "River of Doubt." Here began the long trek into the unknown. The venture these men braved in seven dugouts through and around treacherous rapids in completely unknown territory has few parallels in river exploration. The entire journey lasted over 2 months. Forty-eight days of this time were spent in the unknown wilderness, inhabited only by wild Indians who had, in all probability, never seen a white man before.

During the trip, innumerable rapids and waterfalls had to be skirted by cutting trails and dragging the dugouts overland. One man drowned and part of the precious food supply was lost, when a dugout accidentally ran some rapids. A Brazilian sergeant was killed by another sergeant who ran berserk and escaped into the thicket, never to be heard of again. The party encountered many of the vicious, man-eating piranha fish. This water cannibal, which reaches a length of 18 inches, will devour animals or humans in a matter of minutes. General Rondon related an incident when one of his men was away from camp on a mule. The mule returned to camp alone. In back-tracking, the men came to a ford and found the skeleton of the man, his clothes untouched, but every particle of flesh stripped from the bones. Apparently he had fallen from the mule into the ford, and before he was able to reach the bank the piranhas had disabled and eaten him on the spot.

General Rondon, with the able assistance of Kermit Roosevelt and two Brazilian lieutenants, conducted a stadia traverse along the entire length of the river. Kermit acted as front rodman, and, according to the General, was a very able and practical surveyor. In addition to the stadia traverse, General Rondon selected favorable spots and established astronomic stations all along the unknown river. For the determination of latitude and longitude, the equipment included a Heyde 5-second theodolite, one chronometer, and several stop watches. Understandably, without the aid of modern radio, these stations are of doubtful accuracy, especially in longitude; however, to this day, the only mapping data on this river are the results obtained by the "Expedição Científica Roosevelt-Rondon."

During the long trek down the river, General Rondon honored Kermit by naming the first large tributary "Rio Kermit." Later, when the expedition reached the mouth of the "River of Doubt," the General held a formal ceremony and proclaimed, in the name of the Government of Brazil, that henceforth this river would be known as "Rio Roosevelt." These two North American names have since been accepted by all map and chart compilers and can be found on present maps and charts of Brazil.

PROGRESSIVE MAPPING IN BRAZIL

The control established by the expedition represents the condition of thousands of square miles in the interior of Brazil, especially in the states of Amazonas, Mato Grosso, and Pará. In the research for control, the writer found one area measuring over 100,000 square miles, or about twice the size of our own State of Alabama, that was completely lacking in control of any kind. In other areas, rivers were found displaced on current maps by as much as 36 miles. Some of these displacements are in the process of being corrected.

The Conselho Nacional de Geografia (Council of National Geography) and the Serviç Geográsco de Exército (Army Geographic Service), the two largest federal mapping agencies in Brazil, are fully aware of the existing conditions of their interior. The Conselho Nacional de Geografia is responsible for small-scale mapping of the country and also acts as a repository for all county and state maps and control. This organization has well-trained specialists in triangulation control and map compilation and is progressing favorably with its first-order triangulation nets. Many new, well-presented 1 : 250,000, 1 : 500,000, and 1 : 1,000,000 maps of the Amazonas and Mato Grosso regions are being published, using the small amount of astro or geodetic control and river surveys at hand. The collaborating efforts of the Inter-American Geodetic Survey have accelerated the field work considerably.

The Serviço Geográfico de Exército limits its activities mostly to the south and northeast regions of Brazil. This organization conducts precise triangulation surveys and produces mostly high-quality large-scale maps of 1 : 50,000. Its plant, with efficient army personnel, though small, is an outstanding example of progressive mapping in South America.

Another organization doing good in Brazil, although not in the map-making business, is the Fundação Brasil Central. Its responsibilites assign it to the development of the interior. Its need for good maps is exemplified by the map compilation work of one specialist, Mr. Frederico Hoepken. He worked many months completely revising the planimetric data, from aerial photographs, in one area of approximately 85,000 square miles.

Even though these three organizations, with federal, state, and private mapping agencies, are doing splendid work with the facilities available, it is very apparent that much more effort and support in mapping and charting are needed before this great and respected country can open her interior to civilization and progress. Good maps, which require good control, are the first essential step and the answer to a good start.

* * *

AERIAL SURVEYING

A COURSE to show the use of photogrammetric procedures in solving highway engineering problems was recently given in Sacramento by the U. S. Bureau of Public Roads and the California Division of Highways for highway engineers from Arizona, California, and Nevada. Instruction was by William T. Pryor of the Bureau of Public Roads. The course consisted of a week of lectures and a second week of actual highway location with aerial photographs and stereoscopes.—*Engineering News-Record,* June 14, 1951.

The Education of the Land Surveyor, If and When

By S. A. BAUER

REGISTERED CIVIL ENGINEER AND SURVEYOR, CLEVELAND, OHIO

AT THE RISK of starting a riot, permit me to quote from a resolution adopted by the Conference of British Commonwealth and U. S. A. Survey Authorities in New Zealand, in November 1950 (I shall quote only a bit of the resolution):

> That the functions of a Land Surveyor, as defined in paragraph (1) above, can generally be comprehended under the following main categories:
>
> (*a*) Basic control and Geodetic Surveys, including astronomical, gravitational, trigonometrical, height, and electronic measurements.
>
> (*b*) Topographic Surveys, including instrumental, graphical, and air-photographic measurements.
>
> (*c*) Large-scale Detail Surveys, including instrumental, optical, graphical, and chain measurements.
>
> (*d*) Cadastral Surveys, including the establishment of boundaries.
>
> (*e*) Hydrographic Surveys.
>
> The above categories include the relative computations and preparations of diagrams, charts, maps, and plans necessary to their execution.

In quoting this, I do not propose that such a broad definition of land surveying be instituted in this country. I do not think it would be either feasible or particularly beneficial to us. I quote it only to show the attitude of our British friends towards land surveying. In my visits to meetings of the Canadian Institute of Surveying and Photogrammetry and the Quebec Corporation of Land Surveyors last year, I was surprised to learn for the first time the British attitude toward land surveying, namely, that land surveying in Canada is, to a large extent, considered the end product of surveying and mapping, and that geodesy, photogrammetry, and the other specialties are means toward the end of improved land surveying. Again, I do not think that we in this country are ready for such a distinction, nor would it be particularly advisable.

The only surveying education, beyond the most elementary, as yet available in this country, is limited primarily to the specialties of surveying, often referred to as "higher surveying." The land surveyor remains uneducated insofar as there is any comprehensive plan toward his education in our colleges. For this reason I preferred to entitle this paper "The Education of the Land Surveyor, If and When."

In all questions dealing with the betterment of engineering or surveying, I like to look at the attitudes and methods of the medical profession. That profession, by careful planning, has, within a period of about 50 years, raised its status from that of a collection of witch doctors and 30-day diploma mills to the most esteemed profession today, not excluding the theological profession. Engineering, too, could use some uplifting and might find guidance from our medical friends. Again, the methods of the medical profession, if used, should be used primarily as a guide, rather than something to be copied.

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Viewing the medical profession, we see that their colleges educate students to become *doctors*—not neurologists, psychiatrists, surgeons, pediatricians, ophthalmologists, etc.,—but doctors, general practitioners. After those general practitioners have been out of school and have acquired some general knowledge of the practice of medicine, then, by further education and further apprenticeship, the doctors can establish themselves as specialists in chosen fields, after fulfilling certain requirements of the specialties. The value of the general training first is, of course, apparent.

In our profession the reverse is true. We educate only the specialists. We do not bother with the general practitioner who, in my mind, is of course the land or property surveyor in private practice.

In briefest terms, I would say that the education of the land surveyor should be predicated upon the assumption that he *is* to be the general practitioner in the surveying and mapping field. That being the case, it is apparent that he must have a broader education than is generally thought necessary by those who think it is worth while trying to educate him at all. I would say that he should be entirely familiar with all the instrumentations, methods, and procedures ordinarily used in plane surveying.

One of the less desirable qualities often seen among surveyors is the automatic condemnation of any instrument, method, or procedure that differs from the one with which they happen to be familiar. That is the reason for the blind unwillingness of the American surveyor to accept the foreign instrument with three-leveling-screw support. "It's not accurate," he says. The man who was brought up on the cross section method of topography has a horror of stadia. "It's not accurate," he says. He prefers his old-fashioned cross section method, by which he determines his right angles with a grand sweep of his arms to a position in front of him, sighting along his upraised thumbs. I know personally some surveyors who obstinately refuse to use calculating machines, because they involve the use of natural functions. Again, "They are not accurate," they say. Probably the best thing that any college could do in educating engineers and surveyors would be to abolish from the vocabulary that word "accurate." The education of the property surveyor—and this could apply to all surveyors and mappers—would be advanced greatly by simply eliminating the various fetishes that exist throughout the entire profession.

The education of the property surveyor should include, of course, the necessary mathematics and the practical application of geometry, plane and special trigonometry, and algebra to specific problems of land subdivision, including horizontal and vertical curves, and spirals. There should be included also a very thorough course in the law of boundaries, working from the underlying theories to specific cases, again indicating the variations, exceptions, and modifications within any legal jurisdiction and between legal jurisdictions. The rules of the General Land Office should be included, but since these are readily available in book form and do not permit of the operation of much personal discretion, it should not be necessary to devote too much time to this subject. Some time should be given to engineering surveying, particularly in its more complex forms, such as tunneling, bridge layout, etc. Of course, considerable practice in mapping and drafting should extend throughout the curriculum. Some instruction in the various forms of reproduction processes should be given. An orientation course in geodesy and hydrography should be included. The theory of least squares, at least to the point of adjustment of a quadrilateral with two diagonals,

and a traverse adjustment by the junction point method, should be included. The property surveyor should also have some instruction in astronomy, with special application to the problems of determining meridian, time, and position. Considerable instruction in the law of probabilities should be included. It is my personal belief that a well-rounded understanding of the law of probabilities is necessary for the full understanding of the behavior of compensating errors, which, in turn, is necessary in producing any observational work that attempts to attain precision. I, personally, am partial to the law of probabilities as a subject, for the reason that it is both good training for the surveyor and educational to the individual.

May I say that my own interpretation of an educational study is one that shapes mental processes, leaving a noticeable result upon the student long after the specific facts are forgotten. The law of probabilities approaches mathematical reasoning and develops logical and scientific thinking in a student. In my opinion, priority should always be given to what I prefer to term "educational" courses over those which are primarily training, such as draftsmanship. Any course that combines both, as does a course in probabilities, naturally rates top priority.

Probably one reason for my emphasis on this particular form of mathematics is that some 5 years after graduation from a well-recognized engineering school I first stumbled upon the fact that compensating errors tend to combine as the unit error multiplied by the square root of the number of applications. This discovery was a revelation to me. No such thought nor instruction had ever been furnished me while in college. That knowledge opened up an entirely new appreciation of the work that I was doing and supplied, for the first time, the basis for an intelligent understanding of the components of observational precision.

It is my opinion that the property surveyor's education in the field of photogrammetry will of necessity require greater thoroughness and more time than will be devoted to the other specialties of geodesy, hydrography, etc. The basis for this opinion is my firm belief that the near future will enormously expand the applications of photogrammetry to the point that photogrammetric aids will become a regular tool of the property surveyor. I do not intend to convey the idea that the property surveyor will become a photogrammetrist, but I do think that the property surveyor will use the photogrammetrist and his products with increasing frequency. It is quite common at the present time for the property surveyor to use aerial photographs, when they are available, in connection with his surveys, in order to furnish right in the office a visual record of field conditions. The property surveyor with a relatively small topographic survey to perform is greatly aided if he is fortunate enough to obtain a stereoscopic pair for study under a stereoscope. It does not seem improbable that small and relatively inexpensive plotting devices may be obtainable in the future to supplement and aid in the work of the property surveyor.

I wish to emphasize that I do not contemplate that this photogrammetric application by the property surveyor will in any way compete or conflict with the efforts of the professional photogrammetrist, but will be merely specialized adaptations of photogrammetry to the regular activities of the property surveyor.

Although the education of others than the property surveyor is not within the prescribed limitations of this paper, it would necessarily follow from my statements that the education of the geodesist, the hydrographer, the photogram-

metrist, etc., should contain some orientation into the responsibilities and problems of the property surveyor.

When I was asked by Professor Brinker to prepare this paper, I was, of course, flattered and immediately accepted the task. After I had given some thought to the matter, two facts dawned upon me: (1) it is presumptuous of me to tell the professors how or what to teach; and (2) the whole question is quite academic and possibly futile, in that there appears to be very little chance that any college will do anything about the matter, at least in the near future. I do believe, however, that we of the surveying and mapping profession—all of us—have it within our power to make something of ourselves and our profession. I think there is more than a fair chance that we are actually on the road toward achieving some of the professional recognition about which we have talked for so long. I think that recognition will come first in certain specialized fields, but I believe that ultimately even we "land butchers" are going to come into our own, as well. I think the time will come when civil engineering departments will be eager to take the surveyor and mapper back into the fold on the same level as the structural, sanitary, or hydraulic man. That phenomenon will be brought about only by the continuation of an aggressive program of self-betterment and coordination in the surveying and mapping profession.

The American Congress on Surveying and Mapping has done much in its short life in this direction. During the past 15 years surveying and mapping has advanced phenomenonally. Our greatest weakness has been a lack of willingness to work together. The geodesist and the property surveyor are not poles apart. They are part and parcel of the same program, the welfare of one being dependent upon the welfare of the other. Certainly I need not point out how the welfare of the surveying educator would be improved by a more general recognition of the true value and importance of surveying and mapping as a profession.

Having passed through my first pleasure at the honor of being asked to speak before this group, then having come to the realization that, for the time being at least, such thoughts as I may have are rather futile, I finally arrived at the conclusion that some day in, I hope, the not too distant future, the question will not be hypothetical, but real, and that, through the common efforts of the educator, the geodesist, the photogrammetrist, the property surveyor, the cartographer, and all those involved in the production of surveys and maps, the coming of a new day may be hastened.

Plan to Attend

The Twelfth Annual Meeting

JUNE 11, 12, 13, 1952

Shoreham Hotel, Washington, D. C.

Early Development of Horizontal Angle-Measuring Survey Instruments

By HARRY J. PEYTON, JR.
BALTIMORE, MD.

"The professors of this science (of land surveying) are honored with a more earnest attention than falls to the lot of any other philosophers. Arithmetic, theoretical geometry, astronomy, and music are discoursed upon to listless audiences, sometimes to empty benches. But the land surveyor is like a judge; the deserted fields become his forum, crowded with eager spectators. You would fancy him a madman when you see him walking along the most devious paths. But in truth he is seeking for the traces of lost facts in rough woods and thickets. He walks not as other men walk. His path is the book from which he reads; he shows what he is saying; he proves what he hath learned; by his steps he divides the rights of hostile claimants; and like a mighty river he takes away the fields of one side to deposit them on the other."

—Cassiodorus, 540 A. D.

THROUGHOUT the history of surveying, the right angle has played an important role in its development. The reason for the predominance of the right angle is the fact that it is the simplest relation between two directions and that the square is the simplest division of the horizontal surface.[1]

It is logical then, that the first angular measurements were right angles. This is in evidence in many of the ancient engineering accomplishments that have been brought to light by archeologists—for example, Babylonian survey maps which antedate 2000 B. C., showing irregular polygons subdivided into right triangles and squares; the orientation of the pyramids; engineering work done by King Menes I about 4000 or 5000 B. C. in diverting the Nile past his new capital, Memphis; and hydraulic work by King Amenemhe III, to mention but a few. Although we have almost no written evidence today, it is obvious that angle-measuring instruments must have been known to these ancient engineers. For clarity then, let us divide the time between the origin of such instruments and the eighteenth century, the era of their greatest development, into chronological periods, and discuss the discoveries and improvements that occurred within each of them.

BEGINNINGS IN EGYPT, CHINA, AND BABYLONIA

Surveying, as we visualize it today, began many years before the birth of Christ, and there are vague references to "instruments" possessed by very ancient peoples. Euclid is believed to have applied his mathematical rules to practical surveying in Egypt.[2] The Babylonians were, no doubt, well acquainted

Presented to the Civil Engineering Seminar of Johns Hopkins University.

[1] KIELY, EDMOND RICHARD: Surveying Instruments. *Bureau of Publications, Teacher's College, Columbia University,* New York. 1947, p. 12.

[2] HOSKOLD, HENRY DAVIS: Notes Upon Ancient and Modern Surveying, and Surveying Instruments, Books, Tables, Etc. *Andrew Reid & Co.,* London. 1900, p. 5.

with the Pythagorean theorem as early as 1800 B. C., as were the Chinese about 100 B. C. These facts being firmly established, it is reasonable to assume that some form of the Pythagorean triplets—3, 4, and 5—were used to lay out right angles. In actuality, ropes, the lengths of which were multiples of these triplets, were used. It was soon discovered by the *draggers of the rope,* as surveyors were called then, that these ropes easily became lost or unfit for accurate work. Hence an angle-measuring instrument known as the groma came into being (*see* fig. 1). This instrument, similar to the later surveyor's cross, was not nearly as accurate as ropes that were in good condition, but it was much more practical and lasting. The groma consisted of two wooden bars crossed at right angles. From each of the four extremities hung plummets, or plumb bobs, and the instrument was, as nearly as can be guessed, suspended by hand straps. The only reconstruction of this instrument was made about 1925 by the British Museum from fragments located in their junk pile of antiquities. The use of such an instrument was exceedingly simple, one bar being held in the vertical plane of a known base line and stakes then set in the line of the crossed bar, one beneath the groma and another some distance away.

From an Egyptian wall mural, we have evidence of the use of what today is our carpenter's square. Some large forms of this square are believed to have been used in land surveying, but none exist today. These squares were extremely cumbersome and it is doubtful if they were widely used.

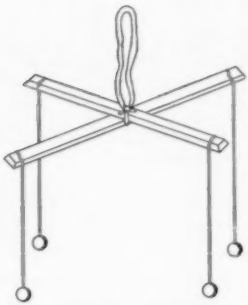

FIGURE 1.—Groma.

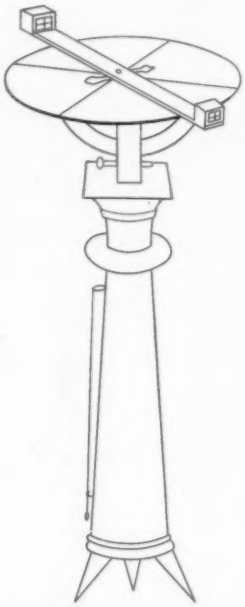

FIGURE 2.—Heron's dioptra.

DEVELOPMENTS IN GREECE AND ROME

"For a clear understanding of the contributions of this period to the development of surveying instruments, it is essential to bear in mind the contrasting attitudes of the Greeks and the Romans toward mathematics and scientific research."[3] The Greeks' attitude toward knowledge was for knowledge's sake, while diametrically opposed was the attitude of the Ro-

[3] KIELY, *op. cit.,* p. 18.

mans. They were interested only in what was of practical value. However, both races did produce a few distinguished men who departed from the educational concepts of their native lands.

Heron of Alexandria was the outstanding exception to the general Greek tendency, being literally the father of the art and theory of surveying. This Greek invented an instrument which he called a dioptra (*see* fig. 2),[4] a device whose value and accuracy were not surpassed until the birth of the theodolite. The dioptra was used interchangeably as a level and a right-angle-measuring instrument. It is peculiar that even though the horizontal plate or circle was laid off into 360 equal parts, existing evidence indicates that only the 4 quarter points were employed in horizontal work. No explanation exists to reveal the reason for not employing all the graduations.

Another contribution of Greece to horizontal-angle measuring was the "Grecian star." This was an improvement of the groma and a very practical one. Instead of holding the instrument by hand, a staff was provided which was directed perpendicularly downward from the horizontal plane of the crossbars and attached at their intersection. Its chief drawback was that it could not be placed directly over a definite point, but, nevertheless, it proved to be even more popular than Heron's dioptra.

Knowledge of these Greek developments was communicated to the Romans and they proceeded to improve them. Most noteworthy was the development of the Roman groma (*see* fig. 3). This, as can be readily perceived from the figure, is a further improvement of the Grecian star. The vertical supporting staff was offset and the cross members were attached thereto by means of a swivel, allowing the intersection of the crossbars to be placed properly above any fixed survey point.

[4] Actually Hipparchus is credited with the invention of the dioptra, but it is best known through Heron's treatise on land surveying, titled "On the Dioptra" in which the dioptra and its use were described.—EDITOR.

CONTRIBUTIONS OF MEDIEVAL EUROPE, ISLAM, AND INDIA

To understand the advances made in Europe in the Middle Ages, one should bear in mind many aspects of the general history of that period. At the beginning of this era, the Western Roman Empire had practically disintegrated and new kingdoms, the prototypes of the modern European nations, were being established. The term *Dark Ages,* which is applied to the beginning of this period, is a misnomer, for the peculiar interest of the early Middle Ages "lies in the spectacle of a civilization struggling to the birth amidst a

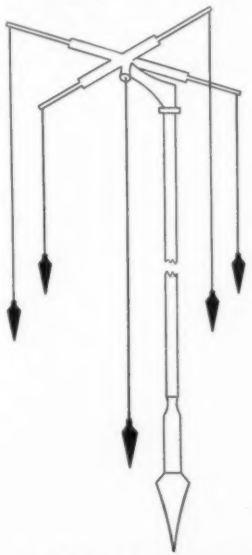

FIGURE 3.—Roman groma.

welter of barbarism; of a gradual conquest of brute force by right, anarchy by law, instinct and passion by reflective intelligence and reasoned purpose; above all, of an ardour of aspiration which, in face of facts that seem at every point to give the lie to the ideal, kept its gaze firmly fixed on the spiritual goal of human life.'"[5]

The climax of European medieval culture came as a result of three major contributions: first, the residue of classical knowledge preserved from Roman times; second, the Moslem reservoir of Greek and Oriental knowledge; and third, the Byzantine depository of the original Greek attainments, which remained almost secret to Western Europe until the end of the Middle Ages.

Contributions to science and knowledge under these conditions of anarchy and ignorant prejudice were indeed difficult, but, nevertheless, the science of surveying developed tremendously. Many of the basic instruments used today were conceived in this turbulent era.

The system of employing right angles as the smallest practical division of the circle still prevailed in the early part of this era. The Moslems retained the squares and ropes of the Romans. Since there is no record of the groma or surveyor's cross, it must be assumed that knowledge of these instruments was lost in the transition period. Rather vague references do exist to relatively great strides in angle measurement by the Indians. This race, in very early times, developed graduated circles and, by repetitious observations, determined true meridians. The Moslems are believed to have employed these Indian circles in determining the direction of Mecca from all important places in Iran. Unfortunately, these instruments were lost and the Moslems in later years reverted to the use of squares and ropes.

It must be remembered that ocean-going trade began to flourish during the Middle Ages and with it the need for navigation aids became imperative. Also, during this period astronomy was becoming a more precise science. In the pursuit of these endeavors, angle-measuring instruments were developed; in fact, the development proceeded in these fields much more rapidly than in the field of surveying. With the exception of those instruments previously discussed, all future inventions and improvements stemmed from navigation and astronomic instruments. Perhaps the best known of these was the astrolabe and its derivatives. The astrolabe was a portable instrument which, as we know from existing specimens, ranged in size from 2 inches to 2 feet in diameter and had a geometric square inscribed on one of its surfaces. With a system of alidades attached to the astrolabe, an angle could be subtended and its trigonometric function read directly from the graduations on the square. The Moslems appear to have played the greatest part in its development as a navigation aid, but the Europeans were the first to apply it to surveying.

The quadrant and its many derivatives are familiar to almost everyone today. The Moslems were first to apply its principles to surveying. To the Europeans again fell the honor of developing practical and accurate instruments of this type. Although the quadrant could be constructed with a large radius, the graduations were usually in units of 2 to 5 degrees. Finer graduations would have been superfluous, as the instrument was held by hand. It was set on a staff only at a later period.

About 1334, Levi ben Gerson, an

[5] By W. G. de Burgh, from KIELY, *op. cit.*, p. 45.

outstanding Jewish mathematician of the fourteenth century, invented the Jacob's Staff. This crude but still-used instrument depended for its operation on the properties of similar triangles; in figure 4 the triangle OXY of the staff is similar to the unknown triangle OAB. Knowing the altitudes of both triangles and the base of the triangle of the staff, distances and angles could be computed.

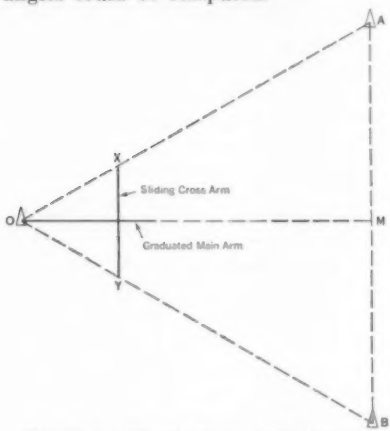

FIGURE 4.—Simple form of Jacob's staff.

Of all early surveying instruments, the magnetic needle has the most intriguing and elusive history in its initial stages of development. The earliest type of needle used consisted of a piece of lodestone shaped as a pointed oval. Before the end of the thirteenth century, artificially magnetized iron needles were in use. Two methods were developed which allowed for free horizontal movement of the needle; one was the wet, or floating, needle and the other was the pivoted type. It is difficult to attribute to anyone or any race the introduction of the magnetic needle, but in its practical application to surveying the Europeans were probably the first.

The earliest reference to the use of the compass is to be found in the ordinances of the City of Massa, set forth in the thirteenth century, relative to the boundary marks in its mines.[6] One ordinance stated that the compass bearing of all boundary lines must be filed in the archives of the municipality for all to see and use in resetting lost property lines.

Georg Agricola, one of the earliest mining experts to put his knowledge in writing, describes, in his "De Re Metallica" (1556), many compasses used in mine surveying. These early compasses were very crude, lacking even a compass card as we know it today. They were made of wood, usually 6 to 8 inches in diameter, and in the center was a depressed circular space for the reception of a small box containing the magnetic needle. Surrounding this and on a raised level part of the face of the instrument, circles with divisions were scribed, and, nearer the periphery of the instrument, there were other concentric circular grooves, each filled with wax of a different color. To perform a survey with this compass, the needle was orientated in the north-south direction, and a string line was stretched along the line of the mine tunnel and across the center of the compass. Where the string crossed any particular wax circumference, a small characteristic mark was made to denote the angle made by the intersection of the tunnel and the prime line. The length of the line and its particular angle mark were recorded. All these data were then taken to the surface and the survey rerun. Thus, it was possible to ascertain any encroachments and to determine the size and wanderings of the mine.

[6] The Encyclopedia Brittanica states that the earliest unquestionable description of a pivoted compass is in "Epistola de Magnete" written by Peregrimus de Maricourt at Lucera in 1269.—EDITOR.

It is interesting to note in passing that many of these early compasses were graduated into 8, 12, or 14 parts per semicircle—originating in the concept of the number and directions of winds. In the most popular type, both north and south were called "twelve hours," and the two semicircles were equally divided and designated with the numbers 1 to 11.

ADVANCES IN EUROPE DURING THE RENAISSANCE

The Renaissance, which covers a period of about 250 years, is undoubtedly the most interesting and the most important period in the development of surveying instruments. The decline of the great manorial or feudal land system brought about individual ownership of property and the need for more accurate definition of land boundaries. For this, far more accurate instruments than had previously been known were required. As is usual, necessity proved to be the mother of invention; in fact, all the developments and inventions are far too numerous to mention herein.

In this period, it is not possible to point out solely developments of horizontal-angle measuring instruments because the idea of combining the various tools for vertical- and horizontal-angle measuring and for leveling was becoming prevalent. This is well illustrated by the invention of the Polimetrum about 1512. This instrument was the earliest prototype of the modern theodolite and transit, containing the two essential devices for the simultaneous measurement of horizontal and vertical angles.

In 1571, Thomas Digges published a book entitled *Pantometria*, which was written by his father, Leonard, before his death. Leonard Digges, the outstanding surveyor of this period, in his book described an invention known as the "instrument topographicall" and one known as the "theodelitus." By a strange quirk of fate, the name "theodelitus" was soon transferred to the "instrument topographicall," and so we have the origin of the name of our present instrument (theodolite), of which Digges' "instrument topographicall" was a prototype.

The great cartographer, Mercator (1512–1594), added an outstanding, but not lasting, contribution to the development of surveying instruments. He combined an ancient but modified astrolabe with a magnetic compass and with this instrument made some of his first mapping surveys. Mercator, himself, in later years, rejected this instrument for one similar to Digges' "theodelitus."

Another great impetus to the development of measuring instruments came from the new science of artillery. Galileo proved that the true trajectory, neglecting air resistance, was a parabola, and the Italian mathematician Tartaglia stated that the greatest range could be obtained from a gun when the barrel was at an angle of 45 degrees above the horizontal. It then became necessary to measure accurately the angle of the barrel, and Tartaglia perfected a very fine gun quadrant with which this could be done. It was soon after this that someone conceived the idea of laying the many vertical-angle-measuring instruments in a horizontal plane and applying them to land surveying. Thus the field was ready for rapid and marvelous improvements and inventions of the type known today.

From the astrolabe came the geometric square with a quadrant divided into divisions of 2 degrees. In later years, a compass was added. The quadrant gave way to a complete circle divided into 360 parts. Cartography

had now developed to a point where the inaccuracy of field measurements was apparent and no longer tolerable. Various men attempted, with some success, to divide the circle into fractional parts of a degree. Several types of interpolating devices were put forth, but it remained for Vernier to take the final step in producing that device, indispensable to all refined measurements, which now bears his name.

It is recorded that the Frenchman Gascoign placed lines in the focus of a telescope as early as 1640.[7] He was the first to place crosshairs, to indicate the focus of the telescope, by means of which its optical axis could be made to bisect distant objects. Picard applied the telescope to angle-measuring instruments in 1669. It was now possible to sight long distances; and this fact, together with the use of the newly perfected vernier, made feasible the great triangulation surveys of this era.

With further combinations, modifications, and improvements, the surveying instruments of today are virtually the same as those of the Renaissance. There was, though, one more revolutionary improvement without which we could never obtain the great accuracy in angle measurements that is so important in modern surveying. The celebrated English scientist and mathematician Ramsden, failing to produce a perfect hand-graduated circle, undertook to construct a dividing-engine. Ramsden did produce such a machine in 1766, and a second and much better one in 1775; its principles are still used today in the dividing-engines for circles of small radii.

Thus, by the end of the eighteenth century, all the important items of the modern surveyor's equipment were in use, even though many were still in rather crude form and some were employed by only a few individuals. The work of the ensuing centuries has been chiefly a process of refinement.

[7] The author is no doubt referring here to William Gascoigne, an English astronomer of note, who placed two movable parallel wires in a telescope about 1638, first outlined and applied tachymetry in 1639 and is credited with inventing the filar micrometer.—EDITOR.

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SEAC Demonstrates High Reliability

LARGE-SCALE ELECTRONIC COMPUTERS have received widespread attention since the war, but only a very few have reached the stage of regular productive computational activity. Since its dedication in June 1950, the National Bureau of Standards Eastern Automatic Computer—SEAC—has demonstrated a remarkable reliability in solving a large number of important problems. Until now, little or no reliable information has been available on any postwar high-speed electronic computer in regular use. The SEAC reliability data are based on actual operation during October through December 1950.

SEAC was developed and constructed by the NBS staff under the sponsorship of the Air Force to provide a high-speed computing service in the application of mathematical techniques to large-scale problems of military procurement and administration. It is also available for solving other important problems of general and special scientific and engineering interest.

Since the new electronic computers are highly intricate with tremendous numbers of components and connections, the reliability demanded of parts and wiring is inordinately high. SEAC contains some 11,000 germanium diodes, 800 vacuum tubes, 500 pulse transformers, and 100,000 soldered connections. Failure even for a millionth of a second of a single one of these myriad connections and components will result in computer misfunction. These factors impose extremely severe design, construction, and maintenance requirements.

SEAC's operations were scheduled on a 24-hour day, 7-day week basis during the 3-month period. In general, of each week's 168 hours, 16 were reserved for preventive maintenance and 76 for engineering development and testing of new computer equipment. The remaining 76 hours were devoted to SEAC's primary mission, the solution of problems.

For the entire 3 months the "good" time was 76 percent of the total assigned to problem solution. Week by week during the period the reliability trend was irregularly upward, with the figure reaching a high of 96 percent for the last week. The "good" portion of the time dedicated to problem solution was that in which (1) either problem solutions or coding checks were turned out correctly; or (2) the machine was in good operating condition but idle. The machine was actually solving problems correctly during more than half (52 percent) of the time assigned to problem solution; coding checks took 17 percent of the time; and during only about 3 percent of assigned time was the machine in order but idle.

"Down" time—28 percent of the total hours allotted to problem solution—was a combination of time lost (1) because of machine misfunction during problem solution (including the time used for rerunning problems); (2) while machine difficulties were being diagnosed and remedied; and (3) while the machine was out of order and idle.

Of the total hours assigned to engineering work, a similarly high proportion—76 percent—was "good" time during which no difficulty was encountered with any machine unit that had previously been put into regular operation.

SEAC produced correct solutions during some 516 hours in the last 3 months of 1950. Since the machine can add or subtract pairs of 14-digit numbers up to 5,000 times per second and multiply or divide them 330 times per second, an enormous number of individual mathematical operations are performed in each functioning hour.—National Bureau of Standards, *Technical News Bulletin,* May 1951.

The Role of Research in Mapping and Charting

By DUNCAN MacDONALD
DIRECTOR, BOSTON UNIVERSITY OPTICAL RESEARCH LABORATORY

WHEN I WAS INVITED to speak before you, I naturally sought some background information about the aims of the Congress. What I have learned in respect to its growth and what I have observed at this meeting indicate the Congress has a glorious future in terms of continued expansion.

I am in a borderline field to mapping and charting. In fact until Colonel Philbrick spoke, I did not realize that we were doing any research in it, which serves to demonstrate the position of research in an operational field such as mapping and charting. So, I wondered if I could bring a worth-while message to you.

A young woman psychologist recently visited our home. She had a problem in explaining what her profession was to her 8-year-old nephew. Finally, she told him that when a doctor seemed to think a patient was sick from worry, and nothing else, he would send the patient to her. But her 8-year-old nephew looked up and said, "What do grown-ups have to worry about?"

This strikes me as a fresh approach to the problem. Confined within the walls of being a "grown-up" we are apt to regard children as living in a happy, carefree world and forget that when we were children, confined within the walls of the reference framework of childhood, we looked at grown-ups as living in a carefree world.

So I thought that perhaps someone outside the field, with a little different viewpoint, without the reference framework of surveying and mapping, might have a fresh idea or two on the problems of research.

Perhaps the agencies involved in the operations of mapping and charting have taken on a rather major responsibility. They are working on the operation, the field work. They are also responsible, or have assumed the responsibility, for development of the operational equipment, and they have also assumed responsibility for the research in the field.

Whenever an operational function attempts to control research, the latter is not performed in the same order of magnitude commensurate with the field operation. Research suffers, due in part to a lack of understanding of what research is and what its function is in the scientific world.

Research performs the function of a sustaining factor. It sustains progress. As Colonel Philbrick said, it is way up on the hill and rolls down through a development channel and eventually into the field. And this sustaining function of research is not recognized by an operational agency.

The typical approach of a user is to come in and say, "I want a box that is X by Y by Z feet." And, if he wants it to go by airplane, he adds, "If I hold it in my hand and take my hand away and it falls, it is too heavy; and it has to do A and B within tolerance C, and I want it."

That is not research. That is pure, straight development. And yet an operational agency, the user of equipment, is continually faced with these problems, and tomorrow it is apt to construe this as being research in the field. It is actually development. Pure research is difficult to set up in the light of field operations.

In many ways—in fact, in all ways—it is impossible to stereotype research. It is difficult to fit it in, for instance, with the Civil Service approach. You cannot make it conform with time-clock routine; you cannot start it thinking at 8 o'clock in the morning and shut it off at 5. It becomes at times a 24-hour job.

May I mention that I feel research is an accumulation which follows the special procedures that constitute what we call the scientific method. In fact, at the outset of a problem the methods and the procedures are far more important than the factual data.

This single point, the collection of procedures for factual data, is perhaps the most difficult one for a using agency to tolerate. So I would say that it is dangerous for operational agencies to be in a position to influence the direction of pure research, for the simple reason that they tend to point it toward short-range projects and tend to make it point particularly toward operational aspects, and this approaches development.

I have mentioned this flow of knowledge. The best illustration that I have seen of the term is contained in a book written by the Levers, a man and his wife, who picture science as a multi-story building. On the first floor we have the salesmen of scientific equipment, the normal, healthy, happy lot. They get along very well together. But they regard everybody in the upper stories of the building as crackpots. They have nothing to do with them, except when a competitor who gets ahead of them in development and comes out with a brighter light bulb forces them to go up to the second floor, and there they talk with their development engineers and their inventors.

The development engineers and inventors are a normal, healthy, happy lot, too, and they mass together the knowledge that exists on the second floor and build the brighter light bulb. Although they regard everybody in the upper stories of the building of science as crackpots, they occasionally have to go up to the third floor to the colllege professors.

Now, the professors on the third floor are also a normal, healthy, happy lot, but they just waste their time puttering around on meaningless things and building up knowledge without any thought of application. Granted, some of the old professors such as Newton, Galileo, and Maxwell did some pretty good work, and it is used every day on the second floor, but the more modern lot is just wasting time. However, it may just happen that this particular light bulb needs a bit more yellow. They would like to find some professor who has been putting lead impurities in glass and find out how to get enough yellow in the light bulb to make it conform to their competitor's. So, they talk about that to the professor.

Of course, everybody up above them in the building of science is a crackpot, the pure mathematicians and the geometricians. To be sure the professors admit that Leibnitz, who developed the calculus, and Euclid, who set up some pretty geometry, were sane men a few centuries ago, but the modern lot is wasting its time with geometry on eggshells.

It is important in this sequence of the building of science to know that the knowledge on one story is about a generation ahead of the knowledge on the floor below. And it is important to maintain this backlog of research knowledge on the third floor and of the pure mathematics on the fourth floor. And it is important to keep feeding this backlog down into the development areas on the second floor and thence out to the salesmen, or into the field.

A classic modern case is probably that of Albert Einstein, who works on the

fourth floor with some strange symbols. Then Bertrand Russell came along with a little philosophy and Sir Arthur Stanley Eddington with some more philosophy and mathematics, and they started running the sun by nuclear energy. And for some 50 years, Russell and Eddington operated the sun as a source of energy on the basis of atomic physics. More recently Hans Bethe devised a more detailed explanation, but I dare say that at the time no one could see the possibilities of an application of such abstract things to the development of anything for mankind.

I am not sure yet that it has been developed for mankind, but you are all aware of the man-made nova, or exploding star, called an atomic bomb, which is the direct result of this accumulation, from pure mathematics down into the third floor of pure research, and finally through the development that took place during the war.

This is a necessary flow of research. I must indicate that the trend here in the American Congress is good. When I heard Professor Harding's suggestions for setting up an educational movement in the field; when I visited his laboratory to observe pure research being conducted in the field, I considered them steps in the right direction. After hearing Colonel Philbrick state for the Air Force that they are in favor of pure research in this field without pointing it toward operations, a research man can only say that the trend is good.

In Dr. Hynek's work, the pure astronomer gets out of an ivory tower, and when you start applying research in astronomy to your field and bring it down from the third floor, then certainly you are on the right track in setting up the research policies.

Good research costs money. It is going to cost the operational agencies money to maintain it, but it will save money and time in the long run.

I have always been advised not to point out the weaknesses and faults of the host organization, but I came down here with a message, and I felt I had to deliver it.

* * *

Institute of Geographical Exploration Closes

THE INSTITUTE of Geographical Exploration at Harvard University closed permanently on October 1, 1951. The Institute, established 20 years ago, gave instruction in cartography, aerosurveying, field communications, field surveying, and exploration in general. Its program was privately financed and directed by Dr. Hamilton Rice, a well-known Amazon explorer.

The Institute's map collection of 102,000 modern maps and atlases is the largest in New England. The library of 20,000 volumes specialized in books on exploration. Instruments were often loaned to explorers, and Dr. Rice sponsored several notable expeditions, such as those of Bradford Washburn, Jr., Arthur B. Emmons, Jr., and many others.

Three years ago Harvard discontinued teaching geography and dismissed its entire staff with one exception. Dr. Rice, discouraged by this policy of the University, finally withdrew his support of the Institute.

The staff is affected. Edward S. Wood, Jr., is continuing private consulting in aerosurveying, and Dr. Erwin Raisz is continuing at his workshop in Cambridge, Mass.

How Accurate is First-Order Triangulation?

By LANSING G. SIMMONS
CHIEF MATHEMATICIAN, U. S. COAST AND GEODETIC SURVEY

THE QUESTION is often asked, "How accurate is the position of a triangulation station," or, "To what accuracy are the distances between triangulation stations known?" These questions are difficult to answer, principally because first-order triangulation gives the optimum accuracy in the measurement of great distances and there is at present no super yardstick to which it can be compared.

THE GEODETIC DATUM

The absolute position of a triangulation station, defined in latitude and longitude, can never be known exactly, because these coordinates are based on astronomic observations. The observations depend on the direction of gravity, usually defined by very accurate spirit levels, and the resulting position is influenced by the local deflection of the direction of gravity in relation to the normal to the spheroid on which the triangulation is computed. (*See* fig. 1.) Even though a great number of astronomic stations are observed in connection with the triangulation of a large country, the positioning of the triangulation on the earth's surface, although much better than that resulting from one astronomic station, is imperfect. The adopted datum point, such as station Meades Ranch in this country, may be in error by as much as 1″ of arc—about 100 feet—in both latitude and longitude. So to begin with, we are on an uncertain footing if we insist that the starting point of the triangulation be correct within a few feet.

The choice of the spheroid to be used as the basis of the triangulation will affect considerably the computed latitudes and longitudes of the stations lying at a great distance from the datum point or origin. For example, holding the position of station Meades Ranch fixed (fig. 2), if the International Ellipsoid were used as the basis for the computation of the geographic positions instead of the Clarke Spheroid of 1866, some of the outlying points would differ in their computed positions by as much as 300 feet in latitude and 130 feet in longitude. This does not mean that the distances to these points from the origin would differ by this amount, but that their geographic positions would do so. This results from the fact that the lengths of the parallels and meridians on the two spheroids differ enough to produce the above result. The dimensions of the two spheroids are as follows:

	International (*Meters*)	Clarke 1866 (*Meters*)
Equatorial semiaxis	6,378,388	6,378,206.4
Polar semiaxis	6,356,912	6,356,583.8

The distances between points in a triangulation network are almost independent of the spheroid adopted so that, cartographically, it makes little difference which spheroid is used in the computations so long as it is reasonably close to the true geoid, or sea level surface. The distances between widely separated points

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in a triangulation net are slightly affected by the choice of the spheroid due to small differences in loop closures developed in the adjustment of the triangulation. This effect, however, is very slight and probably would not exceed 5 meters in a distance halfway across the United States.

INTERNAL ACCURACY

As to the internal accuracy of triangulation itself, irrespective of the adopted datum and spheroid, the lengths of lines in the net are controlled by measured base lines in which standardized invar tapes are used. The lengths of these tapes are known to be in error by an amount no greater than 1 part in 500,000 and probably no greater than 1 part in 1,500,000. This high precision, however, is soon

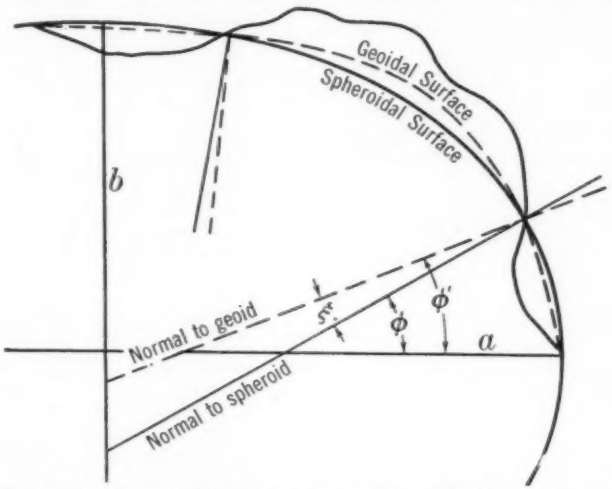


FIGURE 1.—The angle ξ, the component of the deflection of the vertical in the meridian is given by $\xi = \phi' - \phi$, where ϕ is the geodetic latitude and ϕ' the astronomic latitude.

lost because the errors of the triangulation observations make the resulting relative positions of the adjusted work become known to an accuracy much less than this.

ESTIMATED ACCURACY LIMITS

Although we cannot determine the accuracy of the triangulation exactly, because we have no absolute yardstick, we can estimate the limits within which this accuracy might fall from a study of the position closures of the loops and the discrepancies between the measured and computed lengths of the base lines. These base-to-base checks show an average discrepancy of the order of 1 part in 75,000, although at times the limiting accuracy of 1 part in 25,000 is approached. The loop closures developed in the 1927 adjustment of the triangulation in the United States indicate a much higher accuracy, probably due to the size of the loops wherein the errors in such a large number of observations have a chance to balance to a great extent. In the adjustment of the western half of the United States, the average closure for 16 loops (fig. 2) was one part in 450,000, with a

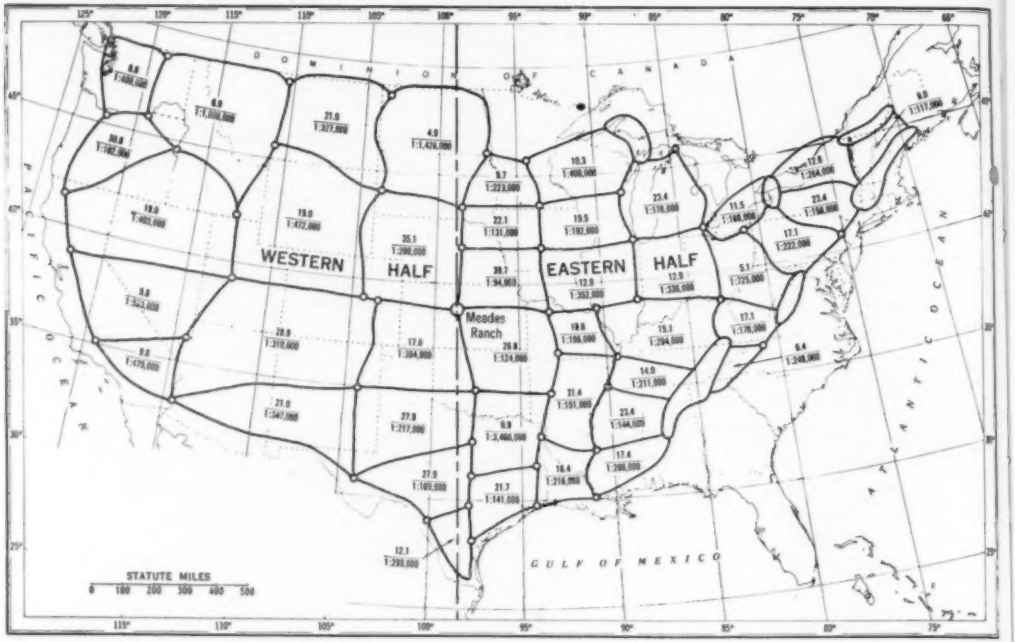


FIGURE 2.—Loop closures resulting from adjustment. The number above the line is the total closure in feet. Below the line is the approximate proportional part of the whole circuit represented by the closure.

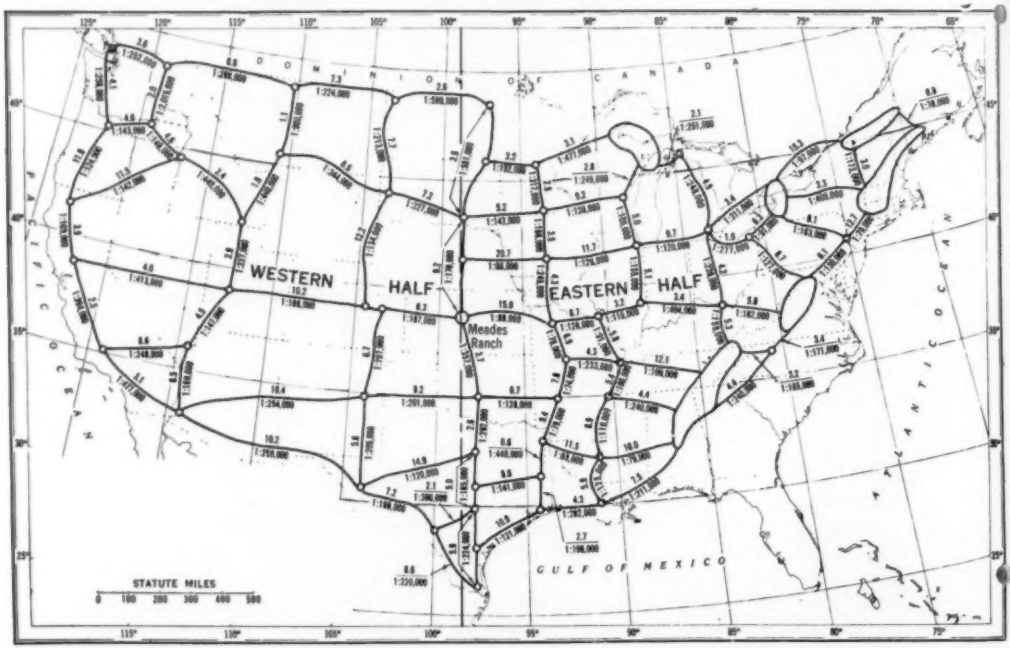


FIGURE 3.—Section closures resulting from apportionment of loop closures. The number above the line is the total closure in feet. Below the line is the approximate proportional part of the length of the section represented by the total closure.

maximum of 1 part in 162,000. A more rigid test would probably be the closures of the sections forming the loops after the junction positions have been adopted, as these reflect to a greater extent the interrelations existing in the triangulation as a whole. For 42 sections (fig. 3) the average closure was 1 part in 317,000, with a maximum of 1 part in 120,000.

In the adjustment of the eastern half, the closures for 25 loops averaged 1 part in 193,000, the largest being 1 part in 94,000. The average closure for 55 sections was about 1 part in 175,000, with a maximum of 1 part in 66,000. So it can be seen that for first-order triangulation involving very large loops, the average precision of the lengths of the arcs appears to be a little better than 1 part in 200,000. On the other hand, it has been found that for a small extension of triangulation in which two or more bases have been provided for length control (such as city work) it is difficult to exceed, for a certainty, an accuracy of 1 part in 100,000 as a base-to-base check.

AN EMPIRICAL FORMULA

It is natural enough to assume that the greater the distance between points, the greater is the proportional accuracy of this distance. An empirical formula is presented as an approximation to the proportional accuracy of distances determined by triangulation. This formula has no scientific basis, but appears to fit the facts fairly well, as we know them, considering its simplicity. The proportional accuracy equals 1 part in $20{,}000\sqrt{M}$, where M is the distance in miles. This is not to be taken as a statement of fact; it merely approximates the average condition.

This method of evaluating proportional accuracy assumes that the stations involved are more or less directly connected by triangulation. This is not always the case. Two stations may be connected by an arc of triangulation a hundred or more miles in length, but actually be only a few miles apart on the ground. If the length of the triangulation arc were 125 miles, the formula would give a proportional accuracy of 1 part in 100,000. But if the stations are actually only 12.5 miles apart on the ground, the relative accuracy of their positioning may be no better than 1 part in 10,000. Because of this ambiguity, this type of triangulation net of long narrow loops with no cross ties should be avoided, if possible.

ACCURACY OF AREA TRIANGULATION

As the large unsurveyed areas are covered by new triangulation connected to the older established arcs, there is a certain loss in proportional accuracy in the adjusted results of the new work, as it must absorb whatever errors remain after the adjustment of the older work. This is so, even though new base lines are inserted, since the new work must, in the end, be fitted to previous adjustments. This situation, however, presents no serious problem if the areas to be filled in are symmetrical in shape. The errors of closure, proportionately speaking, may become greater but their actual amounts remain small.

So we see that it is difficult, if not impossible, to state positively and quantitatively the accuracy in positions and distances in first-order triangulation. The position of a triangulation station is, relatively speaking, an arbitrary thing; it depends on a certain number of selected astronomic stations, the choice of spheroid, the method of adjustment, etc. But once a datum has been established and the triangulation extended and adjusted, we have the best obtainable system of interrelated positions on the earth's surface.

New Astronomical Aspects of Mapping and Charting

By DR. J. ALLEN HYNEK
DIRECTOR, MCMILLIN OBSERVATORY, OHIO STATE UNIVERSITY

Inasmuch as the original paper by Dr. Hynek was profusely illustrated with color shots from V-2 rockets, various astronomical pictures, and photographs of stars in the daytime sky, the following is to be regarded as essentially a summarizing statement rather than a complete presentation of the paper. Space does not permit the inclusion of the photographs necessary to present the original paper.—EDITOR.

AS AN ASTRONOMER I have, of course, always been aware that an intimate connection exists between the stars and the mapping of the surface of the earth. But it was not until I had partially left the ivory tower—or should I say dome—of an observatory to do some work for the Mapping and Charting Laboratory at Ohio State University that I discovered that the relationship between the stars and mapping was rapidly growing closer.

Even my association with the Mapping and Charting Laboratory has not transformed me from an astronomer into one who would be qualified to discuss with you the technical details of matters you make your daily work. So I beg to speak to you as an astronomer and with his viewpoint.

MAPPING THE EARTH BY ASTRONOMIC PHOTOGRAPHY

A number of problems that, for the past century, astronomers have considered peculiarly their own are now coming into prominence in your field. A great common bond between the two fields, though not the only one by any means, is photography. Astronomers adopted this technique rapidly because of the very obvious advantages that the photographic plate has over visual observation. (You will note that I say "plate." Except under special circumstances astronomers have found plate far superior to film.) It is noteworthy that this is the hundredth anniversary of the first astronomical photograph ever taken. One hundred years ago, Bond at Harvard took a picture of the bright star Vega and, soon afterwards, of the moon. He thus started a process which you are now just beginning to use. Lest you take umbrage at this remark, let me hasten to explain. It is only recently that mapping and charting of the earth have been taking place from above, either by airplane or by rocket. For years mapping of the earth was a surface phenomenon.

But what was Bond at Harvard doing when he took the first photograph of the moon? He was starting to map a surface from above. That it happened to be the surface of the moon instead of the earth is purely a relative matter. The problem is the same. One could say that Bond was taking a photograph of the moon from a rocket ship 240,000 miles above its surface—because, from the standpoint of a person on the moon, that is exactly what the earth is—a rocket circling at 240,000 miles.

By the use of telescopes we can bring that rocket closer to the moon—or to Mars as the case may be—and hence photograph from a closer vantage point.

The effect of the rocket ship is particularly striking if the observer uses a large telescope in the following manner: First, he sets the telescope on the moon, seeing, of course, only a very small part of the surface at one time. They, by use

of the slow-motion controls on the telescope, he causes it to sweep slowly over the surface of the moon. The effect is startling; and, as mountain after mountain and crater after crater pass in review, the observer gets the impression that he is looking out the observation window of a space ship enjoying the scenery as he cruises just a few hundred miles above the surface of the moon.

You see, therefore, that the selenographer—the man who maps the surface of the moon, or Selene—shares some of the problems you have when mapping and charting take to the air, to the rocket, or, as probably they soon will, to the artificial satellite.

All this has been by way of introduction to the points I wish to make. No doubt as time goes on, more and more mapping will be done from the air and, especially, from *above* the air. As we have seen, this is a problem with which the astronomer is already well acquainted. What, therefore, has he learned that can be of use to the mapper of the earth? He has been at the job a long time—nearly a hundred years now, photographically, and very much longer visually. Fairly good maps of the moon were available in the seventeenth century, and it may surprise you to learn that 32,856 separate features on the moon have been measured and mapped. These measurements are generally three-dimensional; that is, the heights of crater walls and of mountain ranges are known with considerable accuracy.

Mars too has been mapped, but considerable controversy still rages about the finer details, especially the canals.

In areography, or the mapping of Mars, we come to the first basic point about which the astronomer can be of help. This concerns the matter of the relative roles played by the atmosphere and by the photographic plate in the delineation of fine details. The two are intimately related. The reason the eye is so much better than the plate, despite the fact that its resolving power does not equal that of the best photographic emulsions, is that, while the atmospheric boil, or sky noise (what for several hundred years the astronomer has more simply called "seeing") blurs both images, it does not affect the eye and the photograph in the same way. This is because "seeing" is extremely variable. At times the atmosphere becomes quite steady for perhaps a tenth of a second or so. However, the photograph generally requires a longer exposure, which means that the good moments have to be averaged with the bad. Of course, the bad effect wins. The eye, on the other hand, can capitalize on the moments of rare good seeing. The patient astronomer of the last century, for instance, would sit at the telescope for hours waiting for such moments and then draw what he saw.

Is there no hope for photography? Faster photographic emulsions or faster optics provide a solution. But, generally, the faster the emulsion, the coarser the grain of the plate. So if we cannot control the emulsions, perhaps we can develop faster optics. That is why the 200-inch Palomar telescope may be able to solve the mystery of the canals on Mars by photography. When Mars makes its next close approach on or about September 11, 1956, this greatest of all telescopes will take thousands of photographs on continuous strip film. The great light-gathering power of the telescope will enable the photographer to use shorter exposures. Therefore, out of thousands of individual photographs, perhaps one or two will coincide with those rare instants of good seeing, and the puzzling question of the canals on Mars may be settled once and for all. This emphasizes the importance of "seeing," or sky noise.

Right here you may well say, "But all this mapping of Mars and of the moon calls for large telescopes. We can't mount 200-inch telescopes on rockets, or carry them along on airplanes or even on artificial satellites." Well, of course, we don't need to.

The next point, then, that I would like to examine is this: Given a rocket 500 miles above the surface of the earth, what sort of optical equipment is necessary to *exceed* the detail given by the 200-inch telescope when used to view the moon? The best photographs of the moon today show detail down to about 0.15 seconds = 1,000 feet. The 200-inch telescope could probably get down to 700 feet in practice.

But let us go further than this. Let us suppose that photographic emulsions exist that can take advantage of the full theoretical possibilities of the 200-inch telescope. The theoretical resolving power of this instrument is 0.02 second of arc. This corresponds to a linear distance of 121 feet on the moon. To make use of this theoretical resolving power would require a photographic emulsion having a resolving power of 600 lines per millimeter. No ordinary emulsion has this. The new Eastman 649 does, however, but it is extremely slow. According to some tests run a few days ago by a student of mine, it is some 1,800 times slower than Panatomic X, or 7,000 times slower than Super XX, which makes it almost useless astronomically.

Putting all this aside, however, what optical equipment is needed on our rocket ship at 500 miles above the earth's surface to distinguish points 100 feet apart on the earth? This is better than the 200-inch telescope could do for the moon, even theoretically. At a distance of 500 miles, 100 feet subtends an angle of a trifle less than 8 seconds of arc. Our optics, therefore, must be able to resolve this, and even a 1-inch-diameter lens of good quality can do so. Actually, we would want a larger one, of course, to increase our speed.

Now, assume that we use a photographic emulsion that will resolve 100 lines per millimeter. This is about what a good process plate will do. What focal length must we use, then, so that 0.01 millimeter on the plate corresponds to 100 feet on the earth, 500 miles below us? A simple calculation shows that the focal length required is only 10 inches. This is rather surprising, as one might imagine that fairly elaborate equipment would have to be used aboard an artificial satellite to do for the earth what the largest telescopes in the world can do for the moon. For fast, coarse-grained film, the focal length must be increased by a factor of 4 or 5.

There remains yet a basic assumption in our reasoning: that it is all the same whether you look up through our atmosphere at the moon or down at the earth. This, however, is not the case. When we look out at the moon, light comes through the atmosphere, suffers losses, and is smeared by bad seeing. But should we try to photograph the earth from atop our atmosphere, we should face a somewhat different condition. Sunlight would have to pass through our atmosphere first and be reflected back to our cameras in the rocket. On its first trip through the atmosphere, sunlight becomes scattered, and a goodly portion is directed back into space before it reaches the earth. The atmosphere scatters blue light much more than red, and from our vantage point we should find much more bluish light coming toward us than was in the bargain. The main effect would be to reduce contrast. Much of this disadvantage could be eliminated by photographing in infrared.

I hope that I have made my over-all point—that the problem of mapping the earth from on high, which is more and more with us, is similar to that of the astronomer in mapping and charting other worlds.

Of course, this has been only one illustration of the growing relationship between astronomy and mapping. There are many others. I should like to take time for only one more, this time a problem that has occupied a part of our attention at the Mapping and Charting Laboratory.

PHOTOGRAPHING THE STARS BY DAYLIGHT

It is a well-known fact that, when night falls in the Arctic regions, it stays night for a long while, and conditions are generally quite unpleasant. Certainly that is not the season to be in those regions photographing the stars. Since all geographic positions are ultimately derived from star positions, the question has arisen as to whether it would be possible to facilitate mapping of the Arctic by photographing stars during the daytime. Then helicopters could fly into those poorly charted regions of which Mr. C. H. Ney told us yesterday, do an efficient job of mapping, and be out before nightfall.

To make a long story short, we have investigated this matter in some detail and have developed and used a formula which tells us, not only for photography but also for photoelectric or other detection methods, the limiting magnitude or brightness of a star that can be detected with a given optical system. As a matter of fact, the formula applies to night observations too and is applicable over the range from a hand camera to the 200-inch telescope. It is as follows:

$$m_{lim} = m_{sky} - 2.5 \log (\delta\pi \times 10^{10}) - 5 \log \left[\frac{1.22\,\lambda}{A} + 4.84 \times 10^{-6} S'' + \frac{d''}{F} \right]$$

where m_{lim} is the limiting magnitude; m_{sky} is the magnitude of a square second of sky; δ is the "discrimination," or "contrast sensitivity," of the detector (photographic plate or photoelectric cell); λ is the effective wave length of the incoming light; A is the aperture of the objective in centimeters; S'' is the size of the blur, or seeing disk; d'' is the so-called "turbidity dish" (a measure of light-scatter in the photographic emulsion; this term is used only in the photographic method); and F is the focal length of the optical system in centimeters.

Time does not permit more, but I trust that these two examples indicate the astronomical trends in mapping and charting.

* * *

Government and Industry Short 60,000 Engineers

MORE THAN 60,000 engineers are needed by Government and industry, according to a newly completed survey of over 378 private firms and Government agencies. Cary H. Brown, chairman of the Engineering Manpower Commission of the Engineers Joint Council, discussed this shortage before a recent meeting of the American Society for Engineering Education at East Lansing, Mich.

Mr. Brown blamed the increased demand for engineers on mobilization needs and on the extreme advances in technology of the last several years. Engineering graduates will not be so numerous in the coming years, he predicted. Although this year's classes furnished 38,000, only about 26,000 are expected next year, with the number falling off to about 12,000 in 1954.—*Science News Letter,* July 7, 1951.

Surveying and Mapping News

Members are requested to send in surveying and mapping news items for publication in SURVEYING AND MAPPING.—EDITOR.

CURRENT SURVEYING AND MAPPING LITERATURE

MAGAZINE ARTICLES

THE USE OF DEFORMATIONAL DATA IN EVALUATING WORLD MAP PROJECTIONS. Arthur H. Robinson, *Annals of the Association of American Geographers,* March 1951. (A discussion of the need for a rational basis for evaluating and choosing from the available projections.)

ASTRONOMICAL AND GEODETIC POSITIONS. A. H. Basire, *New Zealand Surveyor,* April 1951. (Discusses a gravity survey in the eastern Mediterranean Sea by a party of British scientists and the fundamental problem of deflection of the vertical.)

BARRIER ISLAND, NOT "OFFSHORE BAR." W. Armstrong Price, *Science,* April 27, 1951. (A proposed terminology to correct the ambiguous use of the terms offshore bar, barrier island, and barrier reef.)

NATIONAL CLAIMS IN ADJACENT SEAS. S. Whittemore Boggs, *The Geographical Review,* April 1951. (The problems of territorial waters are analyzed; an annotated table shows national claims and terms for some 80 countries or colonies; and a map shows adjacent seas claims and waters of the continental shelf.)

SEA LEVEL CHANGES ALONG THE COAST. H. A. Marmer, *Shore and Beach,* April 1951.

THE TIDELANDS QUESTION. L. H. Perez, *Shore and Beach,* April 1951.

AN ANISOTROPIC DRAFTING DEVICE. *Journal of Scientific Instruments,* May 1951. (Describes a drawing aid which reduces the scale of diagrams in one direction and discusses its purpose, design, and operation.)

THE BLUE DOLPHIN LABRADOR EXPEDITIONS, 1949 and 1950. David C. Nutt, *Arctic,* May 1951. (An account of oceanographic and biological research carried out along the coast of Labrador, supported by the Arctic Institute in cooperation with Government and private organizations.)

COPYRIGHT AND THE RIGHT TO CREDIT. Ralph R. Shaw, *Science,* May 18, 1951. (An abstract on literary property in the United States of particular interest to contributors to scholarly journals.)

SUBMARINE TOPOGRAPHY IN THE NORTH ATLANTIC. Ivan Tolstoy, *Bulletin of the Geological Society of America,* May 1951. (Describes and illustrates the submarine topography of the North Atlantic.)

TRANSVERSE PANORAMIC CAMERA PHOTOGRAPHS HUNDREDS OF MILES ON SINGLE ROLL OF FILM. Notes, *CADO—Technical Data Digest,* May 1951. (Describes a new camera taken over by the Air Force which scans *across* instead of *along* the flight path and overcomes shortcomings of present panoramic methods.)

LARGE-SCALE SMALL CONTOUR-INTERVAL TOPOGRAPHIC MAPPING. Louis A. Woodward, *Photogrammetric Engineering,* June 1951. (Emphasizes the need for more efficient camera and instrument equipment, at a cost which the map user can justify.)

A NEW APPROACH TO WORLD DISTRIBUTION MAPS. F. V. Botley, *The Geographical Journal,* June 1951. (Contains suggested methods for improving upon the shortcomings of projections for Asia, the polar regions, and the relationship of continents.)

TOPOGRAPHICAL MAPPING BY HELICOPTER. G. C. Emerson, *Photogrammetric Engineering,* June 1951. (Discusses essentials of topographic mapping by helicopter, citing experiences in British Columbia.)

EARTH CURVATURE AND REFRACTION. J. de Graaff-Hunter, *Empire Survey Review,* July 1951. (Discussion of the requirements and methods of determining the curvature of the earth at a large number of points and the need for research in terrestrial refraction.)

FAST PHOTOS FROM THE SKY. *CADO—Technical Data Digest,* July 1951. (Describes a dramatic development in aerial photography—within 90 seconds after a camera shutter snapped, a picture was processed, inserted in a cardboard mailing tube, and dropped over the side of a helicopter.)

NEW MAPS. *The Scientific Monthly,* July 1951. (Describes some of the topographic maps now available which will eventually be incorporated into the National Topographic Atlas of the U. S. Geological Survey.)

NEW MOBILE FLYING PRINTING PRESS DEVELOPED FOR ARMED FORCES. *CADO—Technical Data Digest,* July 1951. (Discusses a press that provides printing facilities for on-the-spot reproduction of aerial charts, maps, and reconnaissance photographs.)

SOME RECENT REGIONAL ATLASES: A REVIEW. Walter W. Ristow, *The Geographical Review,* July 1951. (Descriptions of recent regional atlases.)

STANDARDIZATION OF STEEL SURVEYING TAPES. J. S. Clark and L. O. C. Johnson, *Empire Survey Review,* July 1951. (The results of investigations on the measurements of steel surveying tapes, in terms of their electrical resistance.)

SUBMARINE CANYONS: A JOINT PRODUCT OF RIVERS AND SUBMARINE PROCESSES. Francis P. Shepard, *Science,* July 6, 1951. (Presents the basis for a new hypothesis explaining the origin of submarine canyons which will be amplified in a longer article now in preparation.)

EARLY SCOTTISH CARTOGRAPHERS. John Bartholomew, *Scottish Geographical Magazine,* August 1951. (An account of the mapping of Scotland.)

THE ARMY'S NEWEST MAP. C. V. Clifton, Jr., *Combat Forces Journal,* September 1951. (Story of the development of plastic relief models for military use.)

BOOKS AND PAMPHLETS

NEW COMPASS OF THE WORLD. Edited by Hans W. Weigert, Vilhjalmur Stefansson, and Richard Edes Harrison. *The Macmillan Company,* New York, 1949. 375 pages, maps, and diagrams. $5.50. (A new symposium on political geography by the authors of "Compass of the World.")

THE OBSERVER'S BOOK OF BRITISH GEOLOGY. I. O. Evans. *Frederick Warne and Co. Ltd.,* London. 1949. 266 pages. 170 illustrations in black, 12 plates in color. 5s.

GEOLOGY OF SOUTHWESTERN SANTA BARBARA COUNTY: CALIFORNIA (Bulletin 150). *Division of Mines, State of California,* San Francisco. 1950. (Includes box of maps and plates.)

NATIONAL TOPOGRAPHIC MAPPING—STATUS AND PROGRAM. W. E. Wrather. *U. S. Geological Survey,* Washington, D. C. 1950. 6 pages. (The story of topographic mapping as a continuing national program.)

OUTSTANDING AERIAL PHOTOGRAPHS IN NORTH AMERICA. H. W. Wanless, O. F. Kotick, and others. *American Geological Institute.* 1950. 87 pages (paper bound). $1.00. (Contains vertical aerial photographs indexed to include names and addresses of agencies holding the negatives.)

THE USE OF GEOGRAPHY. F. Debenham. *English Universities Press,* London. 1950. 206 pages. 6s. (An introduction to a series of "Teach Yourself Geography.")

CALIFORNIA JOURNAL OF MINES AND GEOLOGY. *Division of Mines, State of California,* San Francisco. 1951. 223 pages, and maps of mines and mineral deposits of Inyo County and Darwin Mines.

THE ELEMENTS OF FIELD GEOLOGY. G. W. Himus and G. S. Sweeting. *University of Tutorial Press,* London. 1951. 268 pages, maps, diagrams, and illustrations. 12s. 6d. (A handbook for work in the field.)

THE SPIRIT AND PURPOSE OF GEOGRAPHY. S. W. Wooldridge and W. G. East. *Hutchinson's University Library,* London. 1951. 176 pages, 10 sketch maps. 7s. 6d. (A critical examination of many well-known definitions and a stimulant to a thorough investigation of geography by the reader.)

STAGES AND DISCHARGES. MISSISSIPPI RIVER AND ITS OUTLETS AND TRIBUTARIES, 1949. *Mississippi River Commission, Corps of Engineers,* Vicksburg, Miss. 1951. 300 pages. $1.00.

A TEXTBOOK OF GEOLOGY. Robert M. Garrels. *Harper & Brothers,* New York. 1951. 511 pages, illustrations. $5.00. (One of Harper's "Geoscience Series," to be used by the student, the professor, or the layman in the study of physical geology and the history of the earth.)

TRAITE DE GEODESIE. Pierre Tardi and Georges LaClavere. *Gauthier-Villars,* Paris. 1951. 387 pages, illustrations. $7.49. (Triangulations.)

—A. A. STANLEY

DISTINCTIVE RECENT MAPS

World Air Transportation, Principal Routes of Scheduled Commercial Airlines is the title of a 1951 map published by the National Council of Geography Teachers. The air network is indicated by single black lines. It was compiled by G. Etzel Pearcy, with cartography by Anton B. Fabatz. Fourteen enlarged inset maps show lines serving the major world air terminals. A descriptive summary of world air routes is included at the base of the map. Drawn on the Miller cylindrical projection, the map has an equatorial scale of approximately 1 : 45,250,000. It measures 18½ by 35 inches.

Distribution of Cholera 1816–1950 is the second plate of the American Geographical Society's projected *Atlas of Diseases.* It was prepared by Dr. Jacques May, head of the Society's Department of Medical Geography. The map was published as a supplement to the April 1951 issue of the *Geographical Review,* which also includes an article by Dr. May describing and interpreting it.

The central position on the sheet is occupied by a world map (on the Briesemeister equal-area projection) which traces historical routes of major pandemics. Small world maps outline areas affected during major occurrences. Other maps on the sheet show *Permanence of Cholera 1923–1950,* for Asia, *Egypt Cholera Epidemic Sept. 18th to Dec. 5th, 1947, Monthly Occurrence of Cholera in India,* and *Outbreaks of Cholera 1923–1950* [Asia]. The map sheet measures 25 by 38 inches.

Outlook for Steel shows world deposits of iron ore, coal, the various ferroalloys, and the main iron- and steel-producing centers. Enlarged inset maps show western Europe and northcentral United States. The map, drawn by John Forsyth, is on the Briesemeister elliptical equal-area projection. It measures 11 by 17 inches. The *Outlook for Steel* was prepared to illustrate an article by the same title which is the feature of the April 15, 1951, issue of *Focus,* a monthly publication of the American Geographical Society of New York.

World Crude Oil Production and Refining Capacity is the title of a colorful new map published by Anglo-American Oil Company, Ltd., 44 Queen Anne's Gate, London, S. W. 1. It was prepared by F. H. Reitz. The "map shows the quantities of crude oil and natural gasoline produced in each country, and the intake capacity of crude oil of the refineries in

each country." Parts of the earth most favorable to the discovery of oil are shown in dark green. The three areas in which most oil has been found (i.e., Gulf-Caribbean area, Arabia-Middle East, and East Indies) are encircled in white. A table gives production and refining capacity in metric tons for producing countries. The map measures 25 by 37 inches. No scale is indicated.

Klimatypen der Erde, prepared by Dr. N. Creutzburg, maps world climatic types. The map, published in 1950 by Justus Perthes of Gotha, Germany, was originally prepared to accompany Dr. Creutzburg's article "Klima, Klimatypen und Klimakarten," which appeared in *Petermanns Geographische Mitteilungen,* volume 49, number 2, 1950. Four principal types of climate are distinguished (tropical, subtropical, temperate, and cold) as well as upland and mountain climates. Each type is subdivided into from five to eight subtypes. The map is on the Mollweide projection, with an equatorial scale of 1:50,000,000. The sheet, including legend and symbols, measures 23 by 32½ inches.

Ten Rivers in America's Future, volume 2 of the Report of the President's Water Resources Policy Commission (U. S. Government Printing Office, December 1950), includes a number of interesting maps. One group portrays *Water Resources and Land Use* for the following river basins:

Connecticut River Basin—1:1,800,000, 10 by 9 inches.
Central Valley Basin [California]—1:2,000,000, 9½ by 17½ inches.
Columbia River Basin—1:5,000,000, 10 by 11½ inches.
Potomac River Basin—1:1,600,000, 9½ by 12½ inches.
Colorado River Basin—1:3,750,000, 10 by 13½ inches.
Ohio River Basin—1:3,300,000, 9¾ by 9 inches.
Cumberland River Basin—1:2,250,000, 9¾ by 10½ inches.
Alabama-Coosa River Basin—1:2,380,000, 9¾ by 9 inches.
Rio Grande Basin—1:4,500,000, 9¾ by 19 inches.
Missouri River Basin—1:5,200,000, 9¾ by 17 inches.
Tennessee River Basin—1:1,900,000, 9¾ by 15 inches.

Color tints and conventional symbols indicate existing, under-construction, and projected hydroelectric power developments, as well as major land-use types, canals, reservoirs, navigable waterways, and national parks.

For four of the basins there are separate black and white maps showing *Existing and Potential Hydroelectric Power Developments.* They include:

Central Valley Basin of California—1:7,500,000, 9¾ by 19 inches.
Colorado River Basin—1:3,750,000, 9¾ by 14 inches.
Ohio River Basin—1:3,600.000, 9¾ by 13 inches.
Missouri River Basin—1:5,000,000, 9¾ by 16½ inches.

Hydroelectric power sites of the Connecticut River Basin are shown on a separate colored map at the scale of 1:1,800,000, which measures 10 by 9 inches.

"Areas of Federal Land Responsibilities" are outlined on a map of the Colorado River Basin. National forests, parks, and monuments, Indian reservations, wildlife refuges, and fish hatcheries are identified by appropriate colors or symbols. The scale of the map is 1:6,500,000 and the dimensions 10¾ by 7 inches. Details of land ownership for Colorado and Arizona are shown on small maps on the same sheet.

A map of *U. S. Railroads Classified According to Capacity and Relative Importance* has been compiled by Dr. Edward L. Ullman, Associate Professor of Regional Planning, Harvard University. It was published in 1950 by Simmons-Boardman Publishing Corporation of New York. Appropriate symbols identify lines which have "four and three tracks," "two tracks," "single track," "electrification," "centralized traffic control," and "automatic signals." The map measures 28½ by 43 inches and is at the scale of 1:1,450,000.

A series of medium-scale soil maps of various parts of Greece has recently been received at the Library of Congress. They were prepared between 1939 and 1948 by I. A. Zvorykin, assisted by P. J. Saull and S. E. Vrissimdji. Titles and legends are in Greek and English on four sheets and in Greek and German on the fifth sheet (Island of Crete). Soil types and species are identified on the maps. Scales and dimensions vary. The series includes the following sheets:

Soil Map of the Island Zakyuthos—I. A. Zvorykin, 1 : 200,000, 1939.
Soil Map of the Island Eubola—I. A. Zvorykin, 1 : 200,000, 1939.
Soil Map of Thessaly—I. A. Zvorykin and S. E. Vrissimdji, 1 : 150,000, 1947.
Soil Map of Attica—I. A. Zvorykin and P. J. Saull, 1 : 100,000, 1948.
Bodenkarte der Insel Kreta—I. A. Zvorykin, 1 : 300,000, no date given.

A new hypsometric map of Finland (*Suomen Käsikartta*) by J. C. and S. G. Rosberg was published at Helsinki in 1948 by Söderstrom & Co. It is at the scale of 1 : 2,000,000 and measures 27½ by 20 inches. An inset map outlines the political divisions of the country. The map is issued folded, in a cover which has an index of place names.

The General Directorate of Highways [Turkey] published, in 1950, a *Map* [of Turkey] *Showing Types of Roads and Parts Passable During Different Seasons.* The map was printed by the General Directorate of Geodetic Survey. It is at the scale of 1 : 2,500,000 and measures 12½ by 27 inches. In addition to showing several classes of roads, railroads, towns, villages, scenic sites, and historic ruins, the map portrays generalized relief by graded hypsometric tints.

G. De Agostini, map publishers of Milan, Italy, issued two interesting religious maps in recognition of the 1950 Holy Year. *Italie Terre de Saints et de Sanctuaires* is a pictorial map with small representations of sanctuaries, monuments, and churches sketched on the map at their approximate sites. Full-length portraits of St. Catherine and St. Francis decorate the cartouche, and other saints are pictured on the map proper. The illustrations are well done and the map coloring is quite pleasing. The map dimensions are 26 by 20 inches. No scale is given.

The Catholic World is a colorful map of the world on which are indicated areas peopled by Catholics of Oriental Rite, four areas ranked as to percentage of Catholics of Latin Rite, sites of Eucharistic world congresses, Catholic universities, apostolic delegations, and diplomatic representations. Also mapped are several types of mission territories. Their Eminences the Cardinals of the Sacred College are pictured in their robes of office in the lower right and left parts of the map. A portrait of Pope Pius XII occupies a central position between two groups of Cardinals. The world map measures 24½ by 36 inches.

A preliminary geological map of Chile carries the title *Bosquejo Geologico de Chile.* It was compiled by J. Muñoz Cristi and H. Flores Williams, and enlarged by Juan Brügger. Twenty different formations, ranging in age from pre-Cambrian to Quaternary, are differentiated by colors and symbols. The map was published by the Instituto Geográfico Militar. The country is divided into three sections to fit on a sheet which measures 20 by 22½ inches. The scale is approximately 1 : 3,200,000.

During the period 1941 to 1949, a six-part *Atlas de France Vinicole,* edited by Louis Larmat, was published under the patronage of l'Institut National des Appellations d'Origine. The same editor and sponsor issued, in 1949, a separate map entitled *La France Vinicole.* The map of the country as a whole locates all vineyard and wine-producing regions by different color symbols. Figures on the face of the map give the extent of vineyards in hectares by departments. Inset maps show the major producing areas on a slightly larger scale than the main map. The map, including marginal insets, measures 22 by 30 inches.

The effects of the war upon the population and industrial pattern of western Germany are graphically shown on a large-scale map (1:500,000) entitled *Kriegsfolgen-Karte Westdeutschland 1939–1950*. It was compiled by Karl-Otto Gassdorf and Dr. Manfred Langhans-Ratzeburg and published at Frankfurt a/M in 1950 by Verlagsbuchhandlung Karl-Otto Gassdorf. Color and symbols show the character and status of industries and population of specific areas for before 1939 and in 1950. Two inset maps show the Rhein-Westphalia industrial region and spot bridges which were destroyed and indicate whether they are still damaged or have been rebuilt. The over-all measurements of the map sheet are 72 by 48 inches. A statistical pamphlet of 142 pages supplements the map.

Landform Map of Canada is the latest (1950) in a series of physiographic maps prepared by Erwin Raisz for the Environmental Protection Section of the Office of the U. S. Quartermaster General. Hydrography is by Robert L. Williams. In contrast to previous landform maps of this type, the map of Canada is in color. Water features are shown in various shades of blue, and a rather unattractive shade of brown is used for landforms. The respective colors are also used for names of water bodies and topographic forms and for identifying the descriptive data inscribed on the face of the maps. The over-all effect is distinctly unpleasing and the map is quite difficult to read. The sharp clear qualities of certain earlier black and white Raisz maps are greatly to be preferred. The dimensions of the map are 30 by 35 inches and it is at the scale of 1:6,500,000. Inset maps show Canada in relation to other north polar countries and delimit the physiographic regions of the country.

An agricultural regions map of the United States (*Ètats-Unis D'Amerique*) was compiled in 1949 by the Direction de la Documentation, Secrétariat Général du Gouvernement [France]. Some 20 contrasting color symbols distinguish particular types and areas of agricultural production. Mean annual isotherms, irrigation ditches, and dams are also traced on the map. A small inset map shows generalized land-use regions of the United States. The agricultural map is at the scale of 1:8,000,000 and measures 16 by 24 inches. It was printed at l'Institut Geographique National.

The Soil Conservation Service, U. S. Department of Agriculture, has issued a new map of California showing *Generalized Classification of Land According to Its Capability for Use*. It was prepared in cooperation with the California Agricultural Experiment Station and printed, in 1950, by the Army Map Service. Colors delimit four classes of "land suited for cultivation" and four classes "not suited for cultivation." The map is at the scale of 1:750,000 and is printed on two sheets, each measuring 29 by 41 inches.

The Yale University Library published in 1951 a four-sheet, hand-colored collotype reproduction of a unique manuscript map of the American West by William Clark of the historic Lewis and Clark Expedition of 1804–1806. It carries the title *A Map of Part of the Continent of North America*, and covers the entire western area from the Great Lakes to the Pacific coast and from Vancouver Island to the Gulf of California. The over-all size of the map when joined is approximately 30 by 48 inches. The original map, from which the reproduction was made, has been recently added to the William Robertson Coe Collection of Western Americana at Yale. The collotype reproduction is by the Meriden Gravure Company. Only 100 copies were made.

Diagram of the Planting Districts of Ceylon Showing the Principal Estates is the title of a map published in 1950 by the Surveyor General of Ceylon. It was drawn and printed by the Survey Department. The map is at the scale of 1:190,080, and is printed on four sheets, each measuring 24 by 27 inches. Tea, rubber, coconut, cacao, cinnamon, cardamom, and citronella estates are differentiated by color symbols. Roads, railroads, hospitals, rest houses, post offices, and police stations are also shown.

Carte Ethnolinguistique is a new ethnographic and linguistic map of Indo-China. It was prepared under the direction of L'Ecole Française d'Extreme-Orient and designed and published in 1949 by the Service Geographique de l'Indochine. Twelve different ethnic and language groups are distinguished. The map measures 33 by 23½ inches and is at the scale of 1 : 2,000,000.

The Service Geographique Afrique Equatoriale Francaise, published in 1949 a provisional ethnographic map of Cameroun (*Cameroun Carte Ethnique*). It measures 23 by 16½ inches and is on the scale of 1 : 2,000,000. Boundaries of states, colonies, regions, subdivisions, and tribes are delimited. Figures on the map indicate population of specific tribes. Color symbols show the distribution of Bantus; Semi-Bantus; Paleonegritos and Sudanese; and Hamites and Semites. A table indicates totals for each of these groups.

The soils of Morocco are mapped on the *Esquisse Préliminaire de la Carte des Sols du Maroc.* Twenty-four "soils of plains and plateaux" and 16 mountain-region soils are delimited by colors and symbols. The map, at the scale of 1 : 1,500,000, was prepared by Wladimir Cavallar and published by the Direction de l'Agriculture, du Commerce et des Forêts du Maroc. It was printed in the Moroccan office of the Institut Geographique National. The map measures 22½ by 33½ inches.

Direction of movements of various agricultural and natural products of Nigeria are shown on a *Domestic Trade Map of Nigeria,* published by the Nigeria Survey Department at Lagos in 1949. It is at the scale of 1 : 3,000,000 and measures 16 by 18½ inches. Names of specific products are imprinted in blue on the face of the map along with arrows which indicate the normal movement of the products.

The Government Printer, Pretoria, published in 1950 a *Population Map of the Union of South Africa,* based upon 1946 statistics. The map was compiled by the Department of Irrigation and drawn in the Trigonometrical Survey Office. It is at the scale of 1 : 2,000,000 and measures 32 by 41 inches. Dots of different colors show the distribution of Europeans and natives or other colored races. Native reserves, national parks, rainfall divisions, and urban centers are also mapped.

A new folded map of *Alaska,* indicating the steamship routes from Seattle, Wash., through the inside passage to and through Alaska, has recently been prepared by the Northwest Mapping Service for the Alaska Steamship Company. The map is similar in appearance to a highway map. On one face it contains a map of Alaska, the Yukon, most of British Columbia, and parts of adjacent Alberta and the Northwest Territories at a scale of approximately 1 inch equals 80 miles. The other face contains the inside passage from Seattle through southeast Alaska and the area bordering the Gulf of Alaska as far as Kodiak, in two panels at a scale of approximately 1 inch equals 32 miles. Short descriptive paragraphs about the principal coastal towns and topographic features are included. The map, in color, is exceptionally clear and complete, and measures 18 by 31½ inches. A copy may be obtained free of charge from the Traffic Department, Alaska Steamship Company, Seattle, Wash.

—Walter W. Ristow

SCHOLARSHIPS AT M.I.T.

Two scholarships have been established in the School of Humanities and Social Studies for seniors at Massachusetts Institute of Technology. These scholarships are designed to help engineers meet the problems of human relations frequently encountered in their work, particularly in foreign countries.—*Science,* August 10, 1951.

Books in Review

BRITISH MAPS AND MAP-MAKERS. Edward Lynam. *Collins*, 14 St. James's Place, London. 1947. Third Impression (Revised). 48 pages, 8 colored plates, 22 gravure illustrations. 6s.

Reviewed by H. F. Williams, Madison, Wis.

This little book is as delightful to the eye as it is instructive in its subject. The unusually fine colored plates and gravure illustrations of early maps will be of absorbing interest to modern map makers unfamiliar with them. Here in an evening's enjoyable reading is a valuable, though condensed, 700-year perspective of many branches of surveying and map making. These include property surveying; representation of planimetric, hydrographic, and topographic detail; map drawing, coloring, reproduction, and commercial publication; control and geodesy; decorations and typography; and development of instruments.

The subject is unfolded from the earliest known English-made map of England by Matthew Paris about 1250 to the fifth edition, 1931, of the Ordnance Survey 1-inch sheets. Dates and names abound but this is no dry reading. Highly apt and interesting quotations from early surveyors, map users, and map makers are sprinkled throughout. The effects of maps on history and of historical events on maps are not neglected. Due acknowledgment is given to cartographic advances originated in other lands which have been incorporated in British maps.

A number of jolts—which, after all, are perhaps the book's greatest merit—await the reader. Nearly all of Britain is now covered by accurate maps of 1, 6, and 25 inches to the mile. The reader can contrast this with the coverage of his own land. He may also learn that an old-time surveyor or map maker, confronted with some common problem, met and solved it better than many who followed later. And, similarly, the reader will learn that during certain periods in the history of map making in Britain progress was slow, or even quite the opposite of progress, and he may be led to inquire in this light as to the status of his own present endeavor.

TOPOGRAPHIC MANUAL, PART II, PHOTOGRAMMETRY (Special Publication No. 249, U. S. Coast and Geodetic Survey). Lt. Comdr. L. W. Swanson. *U. S. Government Printing Office*, Washington, D. C. 1949. 570 pages. $3.25, buckram.

Reviewed by William A. Radlinski, Photogrammetric Engineer,
U. S. Geological Survey

This text is the second part of a topographic manual being published in two parts. Part I, as yet unpublished, will contain instructions on field-survey techniques used on topographic mapping performed by the Coast and Geodetic Survey. Part II, the subject of this review, deals with the general requirements of the Coast and Geodetic Survey for photogrammetry and contains detailed procedures for all their office photogrammetric operations.

Although much of Part II is directed mainly towards Coast and Geodetic Survey personnel, it will enable readers from other organizations, both private and governmental, to familiarize themselves with the systematic procedures of the Survey and thereby obtain some valuable suggestions.

Of more general interest to photogrammetrists are chapters 3 and 5. In chapter 3, dealing with photogrammetric theory, the author presents a good basic mathematical analysis, which clearly sets forth the theory of the aerial photograph and stereoscopy. This chapter could serve as a reference for initial and secondary courses in theoretical

photogrammetry. Chapter 5, on map manuscript delineation, is obviously the result of a very thorough study of the subject. In addition to a wealth of information on topographic drafting techniques, 28 pages of symbols and abbreviations are included for reference.

For those interested in multilens camera methods, considerable material is presented on the nine-lens camera and the Reading plotter. These two instruments are Coast and Geodetic Survey developments, and hence those portions of the chapters entitled "Aerial Photography," "Radial-Plot Procedures," and "Stereoscopic Plotting Instruments" which refer to these instruments can be considered original source material.

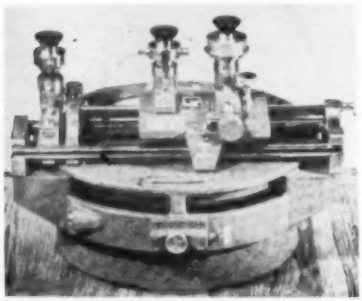
The manual meets all of the requirements of a good textbook. It is well organized and clearly illustrated and contains an excellent index.

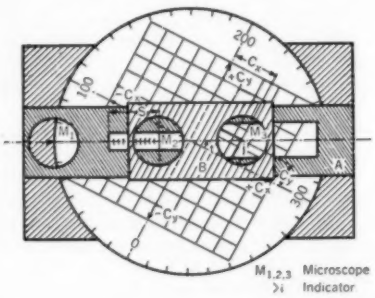
Instrument Mechanically Computes Coordinates

AN INSTRUMENT, called Coorapid, is being manufactured by R. & A. Rost, Vienna, for mechanical computation of rectangular coordinates of survey traverse points without the use of either tables of trigonometric functions or calculating machines.

According to Serge A. Emery, civil engineer of Freeport, N. Y., who furnished the accompanying photograph and sketch and material from which this release was prepared, the Coorapid instrument consists of a horizontal circle graduated in minutes on which the azimuth of the course is set to an accuracy of 0.1 minute by a microscope M_1, attached to the fixed frame A; and a platform B, which is moved along an immobile diameter of the graduated circle, and to which microscopes M_2 and M_3 are attached. When the azimuth of a course is set under microscope M_1, and the length of the course is set under microscope M_2, the rectangular coordinates of the corresponding point can be read under microscope M_3.

The instrument is said to give results equal to those obtained by the use of 5-place tables of trigonometric functions. It readily solves other types of problems involving rectangular triangles, such as reducing lengths measured on a slope to the horizontal; determining bearing and distance from coordinates; orientation in photogrammetry; and checking higher-order computations of coordinates. In the United States and Canada the instrument is sold by Geo-Optic Co., 2416 Atlantic Ave., Brooklyn, N. Y.—*Civil Engineering*, September 1951.





MAP INFORMATION

This department was inaugurated for the purpose of bringing to the attention of the members information pertaining to the availability of maps, surveys, etc., with particular emphasis on how such material can be procured. Authoritative articles covering this class of information are solicited. It is believed that through an interchange and dissemination of such information maximum benefits will accrue to the surveying and mapping profession.

—EDITOR

Topographic Maps

THE FOLLOWING topographic quadrangle maps were published between June 1 and August 31, 1951, by the U. S. Geological Survey (New Publications Lists 515 through 517). All maps are available with or without the green overprint which indicates woodland. The quadrangle name is shown in capital letters, followed by the county name in upper- and lower-case letters. Since many quadrangle maps extend into several counties, only that county name is given which contains the place or feature for which the quadrangle is named. For example, the quadrangle MASON RIDGE, in *Alabama*, is in parts of Morgan, Limestone, and Madison counties, but only Morgan is shown because the feature Mason Ridge is in that county.

Maps of areas east of the Mississippi River may be ordered from the Chief of Distribution, U. S. Geological Survey, Washington 25, D. C., and of areas west of the Mississippi River from the Distribution Section, U. S. Geological Survey, Denver Federal Center, Denver, Colo.

Alabama

HOLLYTREE—Jackson
MASON RIDGE—Morgan
MUD CREEK—Jackson†
PARRISH—Walker†

Alabama-Tennessee

HYTOP—Jackson
KING COVE—Madison

Alaska

BERING GLACIER (A-4)*—Third Judicial Division†
SELDOVIA (C-5)*—Third Judicial Division†
SELDOVIA (D-4)*—Third Judicial Division†
SELDOVIA (D-5)*—Third Judicial Division†

Arizona

MAMMOTH*—Pinal

Arizona-New Mexico

VANAR*—Cochise

Arkansas

BARLING—Sebastian
CAMDEN—Ouachita

Arkansas-Oklahoma

HARTFORD—Sebastian

California

ALLEGHANY—Sierra
ALVORD MOUNTAIN* — San Bernardino†
AVAWATZ PASS*—San Bernardino†
BLOCKSBURG*—Humboldt
CAIRNS CORNER—Tulare†
CAVE MOUNTAIN*—San Bernardino†
CUTTINGS WHARF—Napa
FELLOWS—Kern
FOSTER ISLAND—Tehama
GARBERVILLE*—Humboldt
GERBER—Tehama†
GOLDSTONE LAKE* — San Bernardino†
LANE MOUNTAIN*—San Bernardino†
MARE ISLAND—Solano
MARICOPA—Kern
MOUTH OF KERN—Kern†
NEW YORK BUTTE*—Inyo†
POINT DELGADA*—Humboldt
RED PASS LAKE*—San Bernardino†
REWARD—Kern
TAYLOR MONUMENT—Yolo
TECOPA*—Inyo
TIEFORT MOUNTAINS*—San Bernardino†
TIPTON—Tulare†
TULARE—Tulare†
UBEHEBE PEAK*—Inyo†
VINA—Tehama
WASHINGTON—Nevada
WEOTT*—Humboldt†
WHITTIER—Los Angeles
WINGATE PASS*—San Bernardino†
WOODVILLE—Tulare†

Colorado

HUDSON—Weld
MILLIKEN—Weld†

Connecticut

AVON—Hartford†

* Indicates 15-minute quadrangle; all others are 7½-minute quadrangles.
† Indicates map lies wholly within county named.
‡ Indicates availability in both contour and shaded-relief editions.

COLLINSVILLE—Litchfield
NEW HARTFORD—Litchfield
NORFOLK—Litchfield†
THOMASTON—Litchfield
TORRINGTON—Litchfield

Delaware-New Jersey

DELAWARE CITY—Newcastle

District of Columbia

WASHINGTON AND VICINITY

Florida

BONIFAY—Holmes
CHIPLEY—Washington
COCOA BEACH—Brevard†
FELLSMERE—Indian River
SEBASTIAN NW—Brevard†
TROPIC—Brevard†

Georgia

CALHOUN*—Gordon

Illinois

EFFINGHAM*—Effingham

Illinois-Indiana

DANVILLE NE—Vermillion
DANVILLE SE—Vermillion

Indiana

BUNKER HILL—Miami†
FRENCH LICK—Orange†
HILLHAM—Dubois
INDIANAPOLIS—Marion†
MILFORD—Kosciusko
PERU—Miami†
RICHVALLEY—Wabash
SMEDLEY—Washington†
TWELVE MILE—Cass

Kansas

EDWARDSVILLE — Wyandotte
GRANTVILLE—Jefferson
LAWRENCE WEST—Douglas
MILFORD—Geary
OGDEN—Riley
SWEDE CREEK—Geary
TONGANOXIE—Leavenworth
WIND CREEK—Riley

Kentucky

ANCHORAGE—Jefferson
CRESTWOOD—Oldham
DIXON—Webster†
FISHERVILLE—Jefferson
STURGIS—Union
WATERFORD—Spencer

Louisiana

ARCADIA*—Bienville

Maine

ADDISON—Washington†
COLUMBIA FALLS—Washington†
MACHIAS—Washington†

Maryland

BETTERTON*—Kent

Maryland-Delaware

BARCLAY*—Queen Annes

Maryland-Pennsylvania

FLINTSTONE—Allegany
FROSTBURG—Allegany

Maryland-West Virginia

LONACONING—Allegany
OLDTOWN—Allegany

Minnesota

WHEATON*—Traverse

Mississippi

NEW ALBANY—Union

Missouri

COLONY—Knox
DEER RIDGE—Lewis
KAINTUCK HOLLOW—Phelps†
MEDILL—Clark†
NEEPER—Clark
NEWBURG—Phelps†
ROLLA—Phelps†
WYACONDA—Clark
YANCY MILLS—Phelps

Missouri-Illinois

CANTON—Lewis

Montana

CASCADE*—Cascade†
NORRIS*—Madison

Nebraska

BIG FALLS*—Cherry†
BROWNLEE*—Cherry†
BULL LAKE*—Cherry†
LONG LAKE*—Cherry†
MOON LAKE*—Brown
TURPIN LAKE*—Cherry†
WOLF LAKE*—Cherry†

New Mexico

DORSEY RANCH—Grant†
TYRONE—Grant†
WHITE SIGNAL—Grant†

New York

COWLESVILLE—Wyoming
DRYDEN—Tompkins
HAMMOND—St. Lawrence†
LISLE—Broome
NORTH WILNA—Jefferson
PHILADELPHIA—Jefferson†
SPEEDSVILLE—Tompkins
WHITNEY POINT—Broome
WILLET—Cortland
WYOMING—Wyoming

North Carolina

BRANT ISLAND—Pamlico
CHURCHLAND—Davidson
LEXINGTON EAST—Davidson†
LEXINGTON WEST — Davidson†
NEWPORT—Carteret
WILLISTON—Carteret†
WINSTON-SALEM WEST — Forsyth†

North Dakota

CAMP GRAFTON—Ramsey
CROW HILL—Benson†
HARVEY—Wells
OBERON—Benson†
WESTHOPE—Bottineau†

Ohio-Kentucky

POND RUN—Scioto

Oklahoma

BOKHOMA—McCurtain†
GARVIN—McCurtain†
GOODWATER—McCurtain†
HAWORTH—McCurtain

Oklahoma-Texas

IDABEL SE—McCurtain
TOM—McCurtain

South Dakota

POLO—Hand†
REZAC LAKE—Hyde
RICE LAKE—Hyde†

Tennessee

BELFAST—Marshall
BELLEVILLE—Lincoln
BOONEVILLE—Lincoln
BOONSHILL—Lincoln†
CORNERSVILLE—Marshall
DEASON—Bedford
DELLROSE—Lincoln
HICKORY VALLEY — Hardeman
PETERSBURG—Lincoln
PITCHER RIDGE—Franklin†
WARTRACE—Bedford†

Texas

RATCLIFF—Houston†

Utah

DESERT MOUND—Iron†
THE THREE PEAKS—Iron†

West Virginia-Maryland

MOUNT STORM—Mineral
WESTERNPORT—Allegany

Wisconsin

BLOOMER*—Chippewa†
NEW AUBURN*—Chippewa
RIDGELAND*—Dunn

Wyoming

COTTONWOOD FALLS—Platte†
GUERNSEY RESERVOIR—Platte
THE REEFS—Natrona†

In addition to the standard series of quadrangle maps, reconnaissance maps at the scale of 1:250,000 are being published for both the continental United States and Alaska. Maps in this series published in the period include the following:

Alaska

BAIRD MOUNTAINS‡—Second Judicial Division†
BARTER ISLAND—Fourth Judicial Division†
BIG DELTA‡—Fourth Judicial Division†
BLACK—Second Judicial Division†
BLACK RIVER—Fourth Judicial Division†
BLYING SOUND‡—Third Judicial Division†
BRISTOL BAY—Third Judicial Division†
CANDLE‡—Second Judicial Division
CAPE MENDENHALL—Second Judicial Division†
CORDOVA‡—Third Judicial Division†
DEMARCATION POINT‡ — Fourth Judicial Division†

EAGLE‡—Fourth Judicial Division†
GULKANA‡ — Third Judicial Division
HEALY‡—Fourth Judicial Division
HOLY CROSS—Fourth Judicial Division
HOOPER BAY—Second Judicial Division†
IKPIKPUK RIVER — Second Judicial Division†
KOTZEBUE—Second Judicial Division†
LOOKOUT RIDGE—Second Judicial Division†
McCARTHY‡—Third Judicial Division
MEADE RIVER—Second Judicial Division†
NOATAK—Second Judicial Division†
NUNIVAK ISLAND — Second Judicial Division
POINT LAY—Second Judicial Division†
RUBY‡—Fourth Judicial Division†
SHISHMAREF—Second Judicial Division†
SIMEONOF ISLAND — Third Judicial Division†
SOLOMON‡—Second Judicial Division†
TAYLOR MOUNTAINS‡ — Fourth Judicial Division
TESHEKPUK—Second Judicial Division
TYONEK—Third Judicial Division
UNALAKLEET—Second Judicial Division
UTUKOK RIVER—Second Judicial Division†
WAINWRIGHT—Second Judicial Division†

Arizona

FLAGSTAFF
PRESCOTT
WILLIAMS

California

LONG BEACH‡
LOS ANGELES‡
SANTA ANA‡
WEED‡

Georgia

BRUNSWICK

Georgia-South Carolina

SAVANNAH

Maine

BANGOR
BATH
EASTPORT

Maine-Canada

JACKMAN

Maryland-Delaware

SALISBURY

Maryland-Virginia-North Carolina

EASTVILLE

Massachusetts-New Hampshire

BOSTON

New York

ALBANY
ELMIRA
NEW YORK

New York-Canada

ROCHESTER

Rhode Island

PROVIDENCE

South Carolina

JAMES ISLAND

Virginia

ROANOKE

Washington

VANCOUVER‡
WENATCHEE‡
YAKIMA‡

❦ ❦ ❦

New Electronic System Supplements Shoran

NAUTICAL CHARTS of Bering Sea and the Arctic Ocean have been based on a conglomeration of data collected from many sources. At the close of World War II the Coast and Geodetic Survey began a comprehensive program of basic surveys of these waters. The development of Shoran for control of hydrographic surveys has greatly facilitated these operations.

Inasmuch as the effective range of Shoran is limited by the curvature of the earth, it has been necessary to devise equipment with much greater range to control hydrographic surveys in offshore areas. To meet this need the Electronic Position Indicator (EPI) was developed by the Coast Survey and has been successfully used in the Gulf of Mexico for the past 5 years. Tests have indicated that the ship's position can be determined at any instant with an accuracy of 75 yards or less at distances up to 600 statute miles from the control stations.

In the 1951 Alaska surveying season, EPI was used to extend triangulation control from the mainland to the islands in the Bering Sea. A system of lines was laid out and the distances between stations determined with this equipment or with a combination of EPI and Shoran. Some of the lines thus measured are more than 450 miles in length. One of the lines was also measured with airborne Shoran equipment, using some of the refinements recently made in the instrument and in the operating techniques. Lengths of three other lines were determined by first-order triangulation. Preliminary computations indicate that the probable error of the final positions of the islands will be less than 50 meters. Computations now in progress will yield more conclusive evidence as to the accuracy of measurements made with EPI.

Charted positions of these islands are based on astronomic locations not previously tied to the mainland. The system of trilateration used this year extends the North American 1927 Datum to the islands, bringing them into a common geodetic control system.

Comment and Discussion

The pages of SURVEYING AND MAPPING are open to a free and temperate discussion of all matters pertaining to the interests of the CONGRESS. It is the purpose of this Department to encourage comments on published material or the presentation of new ideas in an informal way. —EDITOR

CIVIL ENGINEERING AND SURVEYING

R. D. COMSTOCK, SR.*—Prof. Milton O. Schmidt's article, entitled "College Training in Land Surveying," in the July–September 1951 issue of SURVEYING AND MAPPING, illustrates the misunderstanding and the occasional bitter feeling that exist between the college-trained civil engineer and the surveying practitioner. I believe that an individual must be both a civil engineer and an *experienced* land surveyor before he can see this problem properly.

Professor Schmidt is quite correct in saying that certain experience is necessary in both activities; opinion may vary as to the amount of experience. It is my opinion that much more time spent in practical experience is needed by the land surveyor than by the civil engineer. This is true because of the hard knocks taken by the surveyor in the course of his work, and the state of mind which he must develop to pursue his work with ease and confidence.

I am one who believes that a college-trained civil engineer makes a poor land surveyor—not that he is incapable. On the contrary, he would be among the best if he were willing to take the time and to assume the peculiar responsibilities that accompany the general practice of land and property surveying.

It is recognized that complications may arise in design and construction as to procedure. However, they are more the exception than the rule. If a certain design job is assigned to an experienced designer, he will proceed with the job with confidence. He knows from his training and experience that a complete and satisfactory answer will emerge from his computations. His responsibility is great, but his training enables him to assume the responsibility with confidence. The construction engineer recognizes a well-designed plan and knows that he will have a satisfactory job from it. There is little doubt in the mind of anyone concerning any phase of the work.

Let us suppose that the designer's computations gave *two* answers, both meritorious and both feasible. Suppose that this happened in a good proportion of his work. Suppose that he knew his decision might lead to litigation, and the decision was solely his—nothing in his reference books or his college training was of any help. This is a situation not generally realized by the civil engineer, but is one in which the land and property surveyor finds himself continually. Court records throughout the nation contain hundreds of boundary line and property disputes, and a good surveyor, like a good attorney, can work up a good case on either side of the argument. There is no doubt that this situation has resulted from poor and inadequate surveying in years gone by, but why condemn the present generation of surveyors for what happened before their time?

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Professor Schmidt complains that 5 years of experience is required in Illinois before one is eligible for land surveying registration. It is probable that this law was written by civil engineers who thoroughly understood the responsibility assumed by the surveyor. It is doubtful whether the rank and file of the surveying profession had any hand in preparing the registration laws of any state in the Union. I, personally, believe that 5 years is not too long for a man to develop the state of mind necessary for successful surveying practice. I do not think the Illinois act ignored the colleges with malice aforethought. It only recognizes the fact that the college is not giving adequate training in this field, and that a man may become a reliable surveyor without college training. He must get it elsewhere.

The professor likewise quotes F. C. Bond concerning "week-end" and "part-time" surveying. This is true only in areas where there are so few surveys that a full-time surveyor cannot support himself in this field alone, or where some hard-headed "business" man imagines he may save a few dollars by ignoring the regular profession. Lack of law enforcement is more to blame for this than individual surveyors.

It is quite true that few land surveyors have adopted the State Coordinate System in their work. It is not that we lack interest or vision, or that we are in a rut over our heads. To tie a corner to such a system requires the same order of work as the system, itself. Land owners are not willing to pay for this added time and effort. Moreover, after a surveyor has operated in an area for a period of years he has developed his own system of control and can easily replace any lost corner which he had set previously.

Much could be written with reference to the last part of Professor Schmidt's article. No college course in land surveying will be successful unless it is administered for the purpose of turning out land surveyors, exactly as courses in steel and reinforced concrete train men for active work in those fields. As the situation is now, it may be nearly described as providing a young man with 4 years of engineering training and expecting him to become a well-qualified land surveyor on his own. Very few will do this, with the consequence that college men stay out of land surveying—they have not the training or the "state of mind" required. Professor Schmidt seems to put the entire blame on the present generation of land surveyors. If we need "new blood," where is it going to be found—in the present ranks of land surveyors or in the colleges and universities? He seems to believe that the surveying profession was once quite reputable but has been allowed to degenerate, which is not the case. Certainly we have progressed in the last 25 years—is not registration a step in the right direction? But should that registration be so easily available to the college graduate engineer that he will be placed in a position for which his college training failed to prepare him?

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Publication of the first five of a new series of state base maps has been announced by Oscar L. Chapman, Secretary of the Interior. The five maps are of Maryland-Delaware, New Jersey, Oklahoma, Rhode Island-Connecticut, and Wyoming. Maps of four other states—Illinois, Indiana, Iowa, and Mississippi—will be available in the near future. Inquiries should be directed to the Director, Geological Survey, Washington 25, D. C.—*Engineering News-Record,* March 15, 1951.

CONGRESS NEWS

Correction

Due to an error it was reported in the July–September issue of SURVEYING AND MAPPING that Capt. A. J. Hoskinson was elected chairman of the Control Surveys Division for 1952, instead of as being elected to the Board of Directors of the Division. By virtue of the constitution of the Division, Mr. Carroll F. Merriam, present ranking member of the Board, automatically becomes chairman for 1952.

Texas Section

We all know that Texas is the largest State and that everything in that State is bigger and better—and they have done it again. Our friend G. W. (Buck) Herzog, chairman of the Texas Section, has forwarded a copy of a report on the Eleventh Annual Meeting of the Congress which was prepared for distribution to the members of the Texas Section. The report contains abstracts, in more or less detail, of practically every paper given at the Annual Meeting. Our congratulations to the Texas Section and to its chairman for a most excellent job. Only the editor and the publications committee realize how much work was entailed in preparing this report. We noticed that "Buck" Herzog occupied a front seat at every session of the Annual Meeting, where he was observed busily engaged in taking notes, but we still don't know how he managed to report on six Technical Division meetings that were held simultaneously.

The Texas Section met November 9th in the Alabama Cafeteria auditorium in Houston, where they heard addresses by two authorities on tides and tidal lands. H. A. Marmer, Assistant Chief of the Division of Tides and Currents of the Coast and Geodetic Survey, gave an illustrated talk on tides and tidal predictions; and Clayton Orn, Chief Counsel of the Ohio Oil Company, spoke on tidal lands as they pertain to Texas.

Fourth Annual Surveying and Mapping Conference, University of Florida

The Fourth Annual Surveying and Mapping Conference was held at Gainesville, Fla., November 1 and 2, 1951. The Planning Committee, under the able direction of Prof. Thomas L. Bransford, provided an interesting and instructive program. Registration totaled 186, including local and out-of-state engineers and surveyors, and engineering students. The registration showed a good representation of American Congress on Surveying and Mapping members.

The objective of these conferences is to afford an opportunity for those inter-

ested in surveying and mapping to discuss their mutual problems and become better acquainted with new techniques and procedures related to the field. The conferences are an activity of the Civil Engineering Department of the College of Engineering, as a service function of the Engineering and Industrial Experiment Station, University of Florida.

The 1951 program completely fulfilled the objective of the Conference. Excellent papers were presented on such items of state-wide interest as surveys for highway location and the availability of useful data from State and Federal sources for the average surveyor. An open discussion of land surveying problems invited full participation of all those in attendance at the closing session. The papers presented on determination of true meridian by observation on Polaris and the construction of a planimetric map from aerial photographs were of more general interest.

The Federal mapping program and the application of certain surveying techniques and procedures to national and international problems were covered by papers presented by representatives of the Fort Belvoir Engineer Research and Development Board, the U. S. Coast and Geodetic Survey, and the U. S. Geological Survey.

The conference closed with a general session of the Surveying and Mapping Section of the Florida Engineering Society.

—EARLE J. FENNELL

Personals

Our President, Gerald FitzGerald, Chief Topographic Engineer of the U. S. Geological Survey, inspected mapping activities in Alaska during July and August. In addition to the Geological Survey, many Federal agencies, including the Army, Navy, Air Force, and the Coast and Geodetic Survey, are cooperating in this project which has been given high priority by the Department of Defense. Mr. FitzGerald reports that modern methods and equipment, including the radar altimeter, Shoran, the helicopter, and the airplane, are especially effective in speeding topographic mapping operations in Alaska.

The Maryland Academy of Sciences has a monthly radio program "Know Your Science" on Baltimore station WBAL. On August 24, 1951, the subject was maps. Carroll F. Merriam, Secretary of the Maryland Academy, interviewed J. O. Kilmartin, Chief of the Map Information Office of the U. S. Geological Survey at Washington, D. C. Both men are active members of the ACSM.

Jon S. Beazley, Florida member of the National Advisory Council of the ACSM, is editor of the Surveying and Mapping News Section, a new feature of the Journal of the Florida Engineering Society

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A conference of photogrammetrists was held in Munich, Germany, in September. Fourteen countries were represented at the conference. Those from the United States who attended were: Robert E. Altenhofen of the U. S. Geological Survey, John Pennington of the Engineering Research and Development Board,

James Webb of the Army Map Service, and Duane Lyon of the Aeronautical Chart and Information Service. Several of those from the United States also visited photogrammetric agencies in London; Paris; Delft, Holland; and Heerbrugg, Switzerland.

About 40 new employees of the Topographic Division of the U. S. Geological Survey attended an in-service training program in topographic mapping at Clemson College this summer. The training program is given cooperatively by the School of Engineering and the Geological Survey. Training was given in classes and in actual field work. Riggs Hall on the Clemson College campus was headquarters for the training project, and field surveying was done in the Townville and Seneca quadrangles, which are in the active mapping program of the Geological Survey. The trainees came from twelve different colleges in Eastern United States. The program was under the direction of W. K. McKinley of the Atlantic Region Office of the Geological Survey.

Prof. Russell C. Brinker, chairman of the newly organized Division on Education of the American Congress on Surveying and Mapping, is now head of the Civil Engineering Department at Virginia Polytechnic Institute. Professor Brinker holds engineering degrees from Lafayette College and the University of Minnesota and has taught at Worcester Polytechnic Institute and at the Universities of Minnesota, Hawaii, and Southern California. During World War II he served as a commander in the Civil Engineer Corps of the U. S. Navy. He is the compiler of a recent book entitled "1575 Review Questions for Surveyors."

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Obituary

With the death on October 7, 1950, of Zalman Leef, a member of the American Congress on Surveying and Mapping, the technical life of the State of Israel lost a most interesting personality. Mr. Leef served since 1936, first as an advisor on land and settlement problems for the Jewish Agency and National Funds in Palestine and later as an advisor on territorial and boundary problems for the Israeli Government.

Although trained as an agricultural engineer, Mr. Leef's scientific inclinations led him to research and mapping work in Palestine. Since 1930 he has compiled a number of maps, based partially on his own survey work, of various areas of the country. Among these is the first scientific map of Palestine in Hebrew, published at a scale of 1:250,000 in two sheets in 1936 and 1947. Up to the present time this map is considered the fundamental and most precise map of Palestine, especially with regard to the identity of historic places and names. In cooperation with Dr. B. Maisler of the Hebrew University, Mr. Leef also compiled a map of *Galilee, Ancient and Modern* at a scale of 1:250,000, issued in 1946 in English.

Perhaps the most outstanding of his achievements is his part in the creation of the Photogrammetric Institute in Jerusalem. After years of study, research, and experience in Switzerland, Italy, France, and the United States, the Institute came into being with the establishment of the Jewish state. In connection with this undertaking, Mr. Leef acquired the most modern American and Swiss photogrammetric equipment and pioneered in aerial surveying in the Middle East. Largely as a result of his efforts, the Institute executes surveying and mapping work, based on the latest photogrammetric methods, throughout Israel in connection with economic and agricultural development.

—N. Leef

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Possibilities for Precision in Selecting Map Projections

THIS PAPER, by Dr. Arthur H. Robinson, discusses angular deformation and its distribution in relation to the land areas of major interest on the map.

About 70 years ago the French mathematician Tissot developed a technique for measuring distortion. He showed that on all map projections an infinitely small circle at any point on the sphere is projected as an ellipse. The deformation values at various points on a projection are derived by analyzing the projected ellipses with respect to the changes which have occurred in area or angular relations. The values may be graphically presented by constructing isometric lines of equal deformation, either angular or areal. Further, it is possible to measure the areas enclosed by succeeding iso-lines and to determine, in the manner of a hypsographic curve, the mean value of the angular or areal deformation for the entire projection. This technique of complete coverage by iso-lines and the determination of mean values is of importance for comparing visually the various projections and is particularly helpful in teaching.

The land masses together with the enclosed seas are usually, however, the foci of interest on world maps. However, the relationship between the pattern of

angular or areal deformation of a particular projection and the land masses plotted thereon is more significant than the over-all pattern or the mean value alone. Consequently, the amount and distribution of the deformation occurring within the land areas is being investigated. Deformation in the Miller Cylindrical and the Homolosine are presented as examples.

Dr. Robinson points out that this approach to the problem of determining the finite deformation inherent in map projections does not answer all the questions that the chooser of projections will have. However, he suggests that it would be helpful if authors who develop new projections, or modifications of old ones, would present at the same time this kind of quantitative analysis of their deformations. Thus, any tendency toward convention or mere inspection on the part of persons selecting a projection would be counterbalanced by precise knowledge. —*Annals of the Association of American Geographers,* June 1950.

Conditions Bring New Demand for Military Maps

THE NEED for military maps can never be satisfied in time of war. Stressing that point, Maj. Gen. Lewis A. Pick, Chief of Engineers, urged the nation's photogrammetrists to exert "every effort of their science to ease the burden of the military." He spoke at a recent meeting of the American Society of Photogrammetry in Washington, D. C.

Pick pointed out that the key to modern map production is photogrammetry—the science of obtaining basic photographic surveys.

"World War II emphasized the importance of maps as military tools," he said. "It is an absolute must today that adequate maps be ready and available for every area in which there is danger of an outbreak of hostilities. This is a tremendous task, and it cannot be accomplished without your help and redoubled efforts."

In contrast to the lack of military maps at the beginning of World War II, Pick emphasized the efficient manner in which adequate maps were supplied for the Korean conflict.—*Engineering News-Record,* February 8, 1951.

Survey of Chubb Crater

The National Geographic Society-Royal Ontario Museum expedition, under the leadership of Victor Ben Meen, has left for Chubb Crater, discovered in northern Quebec during July 1950. Mine detectors and magnetometers will be used in an effort to discover the origin of the 2-mile-wide crater between Hudson and Ungava Bays. The lake in the center will be plumbed to determine its depth, and test borings made of the bottom. A thorough topographic survey of the area will also be conducted.—*Science,* July 20, 1951.

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